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Men and Not Dollars

It is too often true that engineers become so absorbed in the commercial and practical problems of their profession that they do not give any thought to its higher and altruistic aspect. This we believe is due to the general and widespread mistaken view of life, confined to no one class of men in our country. Too manifest is the rampant spirit of crass materialism and the unhealthy desire to make the finest pile of fagots in the form of "the roots of all evil." To live simply for one's self is a form of selfishness that will burn itself out in time. On the other hand, every man of decent character wants a competency to make himself and his family live in a proper manner.

* * *

But, as in all things in this complex and funny world of ours, we should strive for the balanced mean. The ancient Roman philosopher who said that "in the middle of the road was there the safest passage" uttered a truth that again and again has re-echoed in the councils of the sages. We should balance things as we find them with things as they should be and strive to mix the real with the ideal in a common-sense and plain sort of way. So, then the engineer ought to produce commercial results; this, we believe, is his function. But at the same time he should hold to the doctrine that money is a power that must be controlled as any other material power. A water-power producing electric power in an honestly built plant is a fine sight. A water power that sweeps away a dam built by a grafter or an ignoramus is a sight that connotes the thought of the devil, for it embodies an element of evil and disgraces a noble profession. As Lord Francis Bacon says, "I hold every man a debtor to his profession, from the which as men, of course, do seek contenance and profit, so ought they of duty endeavor to be a help and ornament thereto."

* * *

A notable example of professional altruism is evidenced by the withdrawal from the metallurgical staff of one of our large metal companies of an engineer at a period of maximum financial productivity and the assumption by him of a professional position in one of our technical schools. This man has been one of the factors in developing our modern metallurgical processes, not by especial brilliancy, but rather by his well-ordered mind and his practical adaptability. He now has a chance to show his ability to produce engineers rather than metals, and men rather than dollars. That he has the sanity to take this step is, we believe, a proof of his ability to inculcate correct principles of his profession in our sons. We may be a bit old-fashioned, but we believe men are a rather finer and more satisfying product than dollars. This engineer will give more than receive, but in giving will he become richer. For he pays his debt to society and no man can be rich until his debts are paid.

The British Chemical Industry.

The most important clause of the new British patents act, on which we commented in our March issue, requires that the article or process which is protected by patent must be manufactured or carried on to an adequate extent in the United Kingdom after the expiration of four years from the date of the patent. It has been estimated that in the immediate future a sum of at least \$125,000,000 of foreign capital will have been invested in Great Britain in order to comply with the new law. The establishment of branches of two of the largest German chemical works at Ellesmere Fort and at Port Sunlight is already reported. Thus the coal tar industry returns to the country of its birth. But will the new patents act really result in an uplift of the British chemical industry? Prof. F. S. Kipping, in his recent Dublin address to the chemical section of the British Association, answers this question in the negative. "If, in this free-trade kingdom production is cheaper than abroad, the foreign firms which have branches here will be in a position superior to that which they now occupy in their own countries. If, on the other hand, owing to inefficient labor, higher wages, freight and other economic conditions, production is more costly, the superior efficiency and scientific organization of these foreign firms will, nevertheless, enable them to command our home market with the goods made here, and to cut us out in the world market, as they do now with those made abroad." . . . "Although the new patent act will prove to be of great value in many respects, it will do little to foster British chemical trade and the development of British chemistry." . . . "The shadow of the cypress rests upon our chemical trade, and manufacturers do not see their way to employ chemists."

* * *

It is probable that Dr. Kipping is unduly pessimistic. But his able discussion of possible remedies for what is wrong in the interrelation between chemical industry, chemical science, and chemical education, deserves full attention. He emphasizes chiefly the necessity of training the future works chemist in methods of research. He warns us not to imagine that when a chemist thus trained enters the works he should or could immediately become an engineer and a commercial expert. The practical man—that is to say, the man who has a thorough and useful knowledge of some particular manufacturing process—must be trained under practical men in the works, and we must not imagine that a course of evening classes will convert him into an expert chemist. The ideal man who combines high scientific training and sound practical knowledge cannot be produced unless the period of his education is extended to half a lifetime.

* * *

The difficulty sketched by Dr. Kipping is not unknown in this country, nor does it apply solely to the chemical industry. Dr. Kipping looks for remedies by comparing British and German methods. It seems equally suggestive to compare the methods of the chemical and electrical industries. The latter have formerly experienced similar troubles. The most significant and revolutionary change in the organization of our large electrical manufacturing companies is the fact that their sales departments are now recruited from the engineering staff. The salesman is a technical graduate; in these days of eager business competition he must have all the technical knowledge on the

spot. The large electric lighting stations follow the same policy. There are 50 technical graduates on the staff in Denver, and another station recently engaged 20 technical graduates at one time. But we cannot send analytical chemists on the road, says the chemical manufacturer. Of course, not. What the electrical industry does, is to get the best raw material from the universities and technical institutions—graduates who have learned the principles and master them thoroughly. And this raw material is developed into engineers in the works in the course of time; and when any department whatever of the organization needs a good man they are sure to find him. Mr. Carnegie's wonderful success was due to a large extent to putting his best practical steel men on the head of the business departments. What Mr. Carnegie does now in furthering education is in line with the same policy. In the chemical and metallurgical industries (as in others) great importance has been laid in the past on making shrewd business contracts, on controlling raw materials, etc. This is all very proper. But in future more will be needed. Sound business judgment must be based on and amalgamated with sound engineering judgment and the future leaders of the chemical and metallurgical industries will and must be the engineering students of to-day.

The Future of Iron and Steel Demand.

It is useless to deny the statement, when so well attested by the experience of many years, that there is a rhythm in the movements of business activity. In the iron and steel trade particularly startling coincidences are observable, hardly without discrepancies. One might suppose, at first thought, that the iron and steel industry would be less likely than other lines of business to yield to influences of a cyclical nature, on account of its rapid growth, since for many years production has been doubling on an average every nine or ten years. It does yield, however, and it may be that it is this very rapid growth which makes the industry particularly susceptible to such influences. The entire cycle involves a period of something like 20 years, as is clearly attested by many phenomena. Why the time should be 20 rather than some other number of years, efforts have been made to explain. The time has been coupled with the supposed life of a business generation, with the solar sunspot period, as possibly measuring a meteorological period with its effect upon crops, with the presidential term, of which it is a multiple, and so on. Since a more general recognition that business has been moving in cyclical form would lead business men to anticipate the movements and prepare for and, therefore, forestall the unfavorable ones, it is more important to recognize than to explain the phenomena. One important reason why the rhythmic movement is not generally recognized as a means of forecasting the future is the popular superstition that this is altogether a new era, subject to new influences and witnessing new departures.

* * *

Much has been said lately of the necessity of the railroads for strengthening permanent way on account of heavier trains, and the general necessity of substituting steel for wood. In discussing briefly the condition of the iron trade in 1887 and the early part of 1888, the even 20 years ago, Mr. James M. Swank, in the annual statistical report for 1887, said: "The increased weight of trains in late years has called for stronger iron and steel bridges, and many of these were substituted for lighter

bridges in 1886 and 1887. The modern tendency to substitute iron and steel structural shapes for wood in the erection of public and private buildings was everywhere very noticeable in 1886 and 1887." Railroad building and development has shown three distinct rates of movement in the 20-year period. The annual statistics of cars, locomotives and miles of railroad built invite this division so clearly that it seems unnecessary to give them in detail here. Using Poor's statistics, which in general refer to fiscal years, ending the middle of the calendar year of similar designation, the periods are the nine years from 1879 to 1887, inclusive, the six years 1888 to 1893, the five years 1894 to 1898, and then again the nine years 1899 to 1907. The number of locomotives, cars and miles of railroad in existence at the ends of these years has been as follows (the figures for locomotives and cars in 1880 being substituted for those of 1878, as no statistical figures for the latter year were available):

	Locomotives.	Cars.	Miles of road.
1878.....	17,949	556,930	81,747
1887.....	27,275	976,772	149,214
1893.....	36,118	1,241,500	177,516
1898.....	36,746	1,318,700	186,810
1907.....	58,301	2,131,487	228,128

The average annual increase in the periods has been as follows:

(Inclusive)	Locomotives.	Cars.	Miles of road.
1879 to 1887, 9 years.....	1,331	59,977	7,496
1888 to 1893, 6 years.....	1,474	44,121	4,717
1894 to 1898, 5 years.....	126	15,440	1,859
1899 to 1907, 9 years.....	2,395	90,310	4,591

While the annual statistics indicate most clearly that the above are the years which should be selected to mark the termini of the periods, it is well remembered that changes in general conditions occurred just at the times indicated. Remembering that fiscal years are designated, in the case of locomotives and cars, and calendar years in the case of miles of railroad, the bank crash of 1893 occurred in June, or just at the close of the fiscal year 1893; the foundation of the 1899 boom was laid in the fall of 1898 by heavy rail purchases, just a few months after the close of the fiscal year 1898, and the present depression was first seriously felt last October, three months after the fiscal year 1907 ended.

* * *

The above table showed that in the six-year period 1888 to 1893, inclusive, there was less railroad activity than in the nine-year period preceding, there being a moderate falling off in the increase in number of cars and of miles of railroad, but with a slightly larger increase in locomotives. In the five-year period following there was a heavy decrease in all three items. In the next nine-year period there was a duplication of the extreme activity of the nine-year period of 20 years earlier, but it was more in the direction of cars and locomotives and less in the direction of new line built. That is a natural variation. The statistics of mileage refer to miles of railroad, irrespective of track, and in the later period there was much double tracking, which does not appear, but naturally involved a great increase in rolling stock. These three classes of statistics each have their bearing. The facilities are interdependent. It would be convenient to reduce the figures to a common denominator and add them. This reduction can be accomplished by a method which at first glance may appear a trifle weird, but which, on reflection,

has much to commend it. The total increase in locomotives in the entire period under review is just about one-thirtieth, in point of numbers, of the increase in cars, while the increase in number of miles of road is just about one-fourth the increase in number of cars. If, then, we multiply the number of locomotives by 30, and the number of miles of road by four, we shall be given about equal weight to each of our three classes of statistics, and adding the numbers together we have the following index numbers to railroad expansion and improvement in the periods:

Annual average.	Index number.
1879-1887.....	129,921
1888-1893.....	107,209
1894-1898.....	26,656
1899-1907.....	180,424

* * *

The impression has remained that 1887 or 1888 ended the period of heavy railroad building, and such was the case, as relates merely to the miles of new railroad built. In 1887 there was an increase of 12,876 miles of railroad; in the next year the increase was 6900 miles, while in no subsequent year has the increase reached 5500 miles. There was not a cessation of railroad activity, but following 1887 there was a diversion of the money to a different class of improvements. Just now there is an impression in some quarters that last year has probably marked the end of heavy railroad expenditure for some years to come. There have been, it is true, very heavy increases in rolling stock, and not a great deal of expansion in that direction is probable. In the direction of new and heavier bridges, heavy rails to replace light or worn-out rails, improvements to terminals, and in other ways, there is left a great deal of expenditure to be made by the railroads. There will necessarily be some change in the direction of the expenditure, but quite likely the decrease in the total sum may not be greater than the slight decrease from the period 1879-1887 to the period 1888-1893. The question of the ability of the railroads to expend large sums of money on improvements has been taken out of its bearing, to an extent, by the propaganda which have been circulated to disarm sentiment against an advance in freight rates. Of late the movement has assumed the form of an organized campaign. Claims are made that the rate of revenue is insufficient to permit the making of absolutely necessary repairs and improvements. As a matter of fact, the railroads have introduced many economies, the effect of which cannot be observed both from the lateness of their introduction and from the fact that the amount of business being done by the railroads in the carriage of freight and passengers is abnormally low.

* * *

If it be admitted that the iron and steel trade is under cyclical control, the evidence for prosperity in the next few years is excellent. Despite the moderate reduction in railroad expenditures in the period 1888-1893, the iron and steel trade was quite prosperous. There was a setback in 1888, similar in its nature to the one being experienced at present, but in the following four years there was a steady and satisfactory flow of business. The increased capacity was engaged, the railroads taking less and other consumers more, than in the previous period. All present indications point to a repetition of that experience.

New York Meeting of American Electrochemical Society.

The annual meeting of the American Electrochemical Society will be held in New York City on Oct. 30 and 31. The preliminary program has been arranged as follows:

Headquarters for registration and information will be at the Hotel Cumberland, Fifty-fourth Street and Broadway. This was also the hotel headquarters last year. On Thursday, Oct. 29, a meeting of the board of directors will be held at the Chemists' Club in the evening.

The general meeting will begin on Friday, Oct. 30, at 9 a. m., with a session devoted to reading and discussion of papers at the Doremus Lecture Theater, Chemistry Building of the College of the City of New York. At 12:30 a luncheon will be tendered to the society by the staff of the department of chemistry, College of the City of New York, Alumni Hall, Main Building. This will be followed by another session for the reading and discussion of papers beginning at 2 p. m.

In the evening an informal subscription dinner will be held.

On Saturday, Oct. 31, a session for the reading and discussion of papers will be held at the Chemists' Club beginning at 9 a. m. Lunch will be taken at 1 o'clock at the Hotel Cumberland and an excursion will be made in the afternoon.

The meeting will be closed by a smoker of the Chemists' Club in the evening.

Details of the program will be published in our next issue, which will be mailed four days in advance of the meeting.

Production and Prices of Non-Ferrous Metals.

The *Metallgesellschaft* and the *Metallurgische Gesellschaft A. G.*, of Frankfurt-on-Main, have just issued the 14th annual volume of their Comparative Statistics of Lead, Copper, Spelter, Tin, Aluminium, Nickel, Quicksilver and Silver.

The great care with which these annual statistics are prepared and their authoritative character are well known.

In the introduction it is pointed out that the year 1907 will figure in the history of metals as the year of extremes, so wide a range between the highest and lowest daily prices having scarcely ever before been known during the last 30 years. The range of price variation (i. e., the difference between the highest and lowest prices in 1907) was

For lead	£9.10	or 42.2 per cent
" copper	57.10	" 51.3 " "
" spelter	8.17/6	" 31.5 " "
" tin	8.5	" 42.5 " "

The percentage figures represent the range of price variation in per cents of the highest price in 1907.

"It would be idle to attempt, upon the lowest prices of the above-named metals during the last 30 years, to base conclusions as to the future, seeing that, on the one hand, these lowest prices in every case ruled only for a brief period, and that, on the other hand, the conditions both of production and of consumption of these metals have undergone important changes. Worthy of special mention is the fact that the cost of production in most of the chief mining districts has risen very considerably, in consequence not only of the advance in wages and price of materials, but also, in part of the deposits becoming poorer, more difficult mining conditions, etc., so that many mines have already reached the limits of profitable production.

"The necessity of adapting oneself to the altered conditions of things, due to the lower level of metal prices, should doubtless bring about a reduction of the cost of production below the level prevailing during the boom, but it must be observed, that in many mining districts the low costs formerly ruling can never again be attained.

"So sharp and swift a fall on the metal market must naturally exert much more unfavorable effects upon the mining industry

than more gradual declines, as these latter more readily permit of owners accommodating themselves to the altered circumstances by means of a gradual reduction of cost, effected through economies and improvements.

"The same thing is, of course, equally true of smelting works. Those which commenced operations during the period of great prosperity and were only gradually able to develop their production, must also be seriously affected by the falling prices. Similarly with those smelting and rolling works whose regular working stock—as not infrequently happens—had been taken into the accounts at the prices ruling when the books were made up, and hence, during the prosperous times, had been valued at a higher rate year by year; the fictitious earnings thus shown disappears, of course, now, when the lower prices have to be reinstated.

"The unfavorable position of the metal market during the past year was reflected, during its closing months, in the state of consumption, and also in that of production, especially in the United States. The world's production of spelter alone shows a notable increase, which, however, is both absolutely and rela-

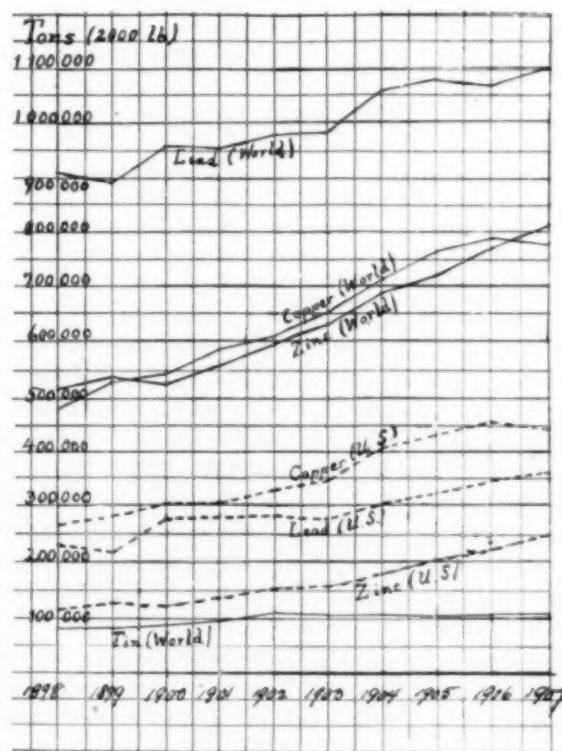


FIG. 1.—PRODUCTION OF METALS.

tively inferior to that of the preceding year, while the total production of lead, copper and tin underwent no change of importance."

After these introductory notes, general summaries are given of the lead, copper, spelter and tin industries, followed by a comparative statement of the Anaconda Copper Co.'s balance sheets and the eighth annual report of the American Smelting and Refining Co.

The bulk of the volume is taken up by comparative statements (in form of statistical tables) on the production and consumption and prices (also exports and imports) of lead, copper, spelter, tin, aluminium, nickel, quicksilver, and silver.

From the enormous amount of statistical information, contained in these pages, it seemed worth while to collect a few of the most important figures and present them to our readers in form of curve sheets. This is done in the adjoining Figs. 1 and 2. These curves supplement those given on page 40 of our

issue of January last, in which the price fluctuation of the different metals during 1907 was shown.

In the adjoining Fig. 1 the fluctuation of the yearly production of metals in the last 10 years for 1898 to 1907 is shown. The drawn-out curves represent production in the world, the dotted curves production in the United States. The figures

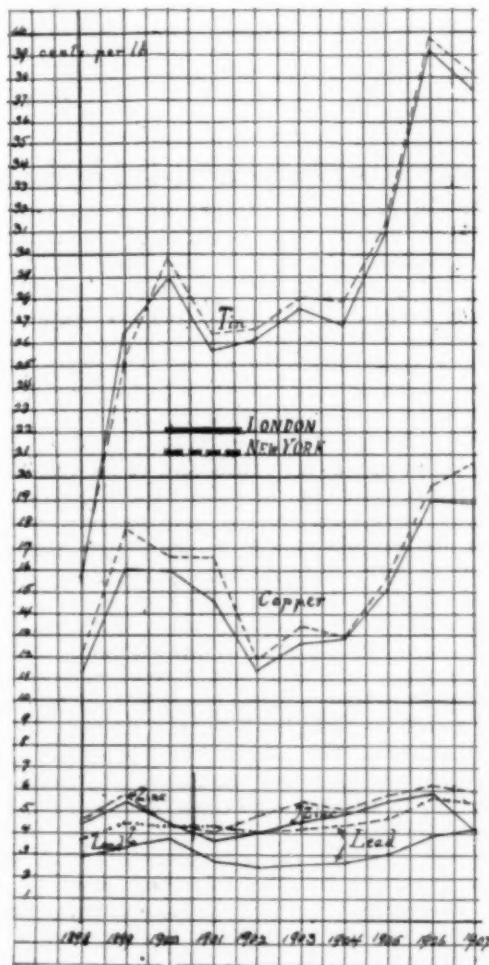


FIG. 2.—PRICES OF METALS.

represent short tons (of 2000 lb.). These curves are plotted from the figures on pages XV, XII, XVIII, XX and 5, 4, 2, and 12 of the Statistics of the Metallgesellschaft.

Fig. 2 shows the fluctuation of the prices of metals in the last 10 years for 1898 to 1907. A mean price is inserted for each year. The drawn-out curves represent London prices, the dotted curves New York prices. These curves are based on pages 97 (standard copper, London), 96 (Lake copper in New York), 92, 94, 106, 107, 108 (foreign tin in London and comparative prices in New York and London), of the Statistics of the Metallgesellschaft.

We trust that both curve sheets will prove interesting. We are obliged to Dr. Franz Meyer, treasurer of the Metallurgical Company of America, for placing the statistics of the Metallgesellschaft at our disposal, and to Mr. H. M. Burkey, engineer of the Metallurgical Company of America, for having compiled and drawn the curves of Figs. 1 and 2.

The Iron and Steel Market.

Purchases of steel products continue to be confined to material required for prompt delivery, so that market activity and production continue to run quite closely together. There has been no more activity in September than there was in July and

August. Producers have not gained anything, but, on the other hand, it is insisted that they have not lost anything, in the month.

The hope has been renounced that there will be any material improvement before the election, if, indeed, there is any before the beginning of the new year. In the spring the "conservative optimism" so much referred to looked for a steady improvement through the year, to an arithmetical increase which would bring the steel industry to a point not far from full operation by the close of the year. Toward the end of May the market became more dull, and remained so during June. In July there was an improvement, and fresh predictions were at once made that there would be a progressive improvement through the year. These expectations also have failed.

The position at this time seems to be that certain light lines, particularly wire products, sheets, merchant pipe and merchant steel bars, have undergone a fairly steady improvement since about June, with prospect of nothing more than a moderate further improvement in the next two or three months, while certain heavy lines, including rails, shapes and plates, have been holding their own since June, but with the prospect of tapering off as the season advances. It is the change which occurs every year at this time, as in years when production is quite uniform through the year there is this change in the distribution of the material. Too much stress has been laid upon the improvement noted in these light lines in the past two or three months; it is a normal thing, and does not ordinarily presage an improvement in total tonnage.

Indeed, it is far from certain that the activity of August and September will be fully maintained through the year. The rate of pig iron production in these months has been about 16,000,000 tons annually, against an average of a trifle under 14,000,000 tons during the first half. There are suspicions that some of the merchant pig iron production has been going into stock, and that some stocks of finished steel products have been accumulated by mills.

The trade at large does not seem to anticipate any quick return in the direction of full activity at the first of the year. Indeed, the predictions are rather less hopeful than one would be led to expect considering the predictions which were freely made earlier in the year, which predictions did not seem to be in line with the tendencies and have not been borne out by events. There is much more reason to expect a return to moderately full activity within six months now than there was to entertain such an expectation six or nine months ago. The year 1908 was marked to be an off year, in characters quite easily decipherable, and it now seems equally clear that 1909 is marked for a year of moderately full activity. While the consumption of iron and steel in this off year is fully equal to the consumption in the boom year, 1899, conditions as to consumption have changed radically and it does not seem possible that the country can long continue at the reduced rate when it is considered that finance and business have really been put upon a pretty sound basis and the crops are distinctly favorable. The lethargy in the iron and steel trade may not disappear as suddenly as activity disappeared late last year, but the disappearance is likely to be more sudden than seems now to be expected.

Pig Iron.

Pig iron has been very quiet in all districts. On the whole, September has probably been the dullest month of the year. This is accounted for chiefly by the fact that there was a little forward buying in July and August. It did not appear to be heavy, at the time, but now it seems that it was heavy enough. Consumption is probably at as good a rate as it was earlier in the year. New England consumers were shrewd buyers in the summer, the lake front and eastern Pennsylvania furnaces pitting themselves against each other in that territory. As a result of business thus booked, with some local buying, the eastern furnaces have advanced prices about 25 cents, to \$16.75, deliv-

ered Philadelphia, for No. 2 X foundry. During the month Chicago district furnaces reduced their asking prices 50 cents, to \$16.50, delivered Chicago, finally recognizing the competition of Ohio furnaces which were underselling them in their own territory. In the valleys, Bessemer and basic have yielded about 25 cents a ton, to \$15 for Bessemer and \$14.50 for basic, while No. 2 foundry remains, nominally at least, \$14.50. The Southern furnaces remain pretty firm at \$12.50, Birmingham, but a little re-sale iron is offered at concessions.

Billets and Sheet Bars.

The billet market has continued extremely quiet. Although the spread between pig iron and billets is now almost \$10, the billet price of \$25, Pittsburg, seems to be quite well maintained. It is believed that shading has been indulged in occasionally, but the details of such transactions are carefully guarded. The sheet bar price is very well maintained, and it is understood that an order for 10,000 tons was offered, at a concession of a dollar from the official price, without finding a taker. The regular basis is \$27, Pittsburg. The movement from the mills is hardly as heavy as it was, since the tin-plate industry is running at a greatly reduced rate, the sheet industry improving slightly.

Finished Materials.

No rail business of any consequence has been placed and at this late date there is no prospect of any buying for this year's delivery. The production of rails in the past few months has been at between 25 and 35 per cent of full capacity, and is likely to decrease. Plates and shapes show no change from July or August. Steel bar specifications in September have been at the better rate shown in August, but there has been no further improvement since then. Demand for wire products has improved, and it is claimed the mills are running at 75 per cent or more of their full capacity. Between 60 and 65 per cent of the sheet mills have been in operation in September, demand showing a slight improvement, particularly for galvanized. Some of the Pacific Coast jobbers have placed some orders for stock. The tin plate season is over. About one-half the leading interest's tin mills ran during September, a somewhat larger proportion of the independents operating. Prices remain as follows, f.o.b. Pittsburg, except where otherwise specified.

Standard rails, 50-lb. and heavier, \$28, f.o.b. northern mill.

Light rails, 25 lb. to 45 lb., \$23 to \$24.

Plates, tank quality, 1.60 cents.

Shapes. 1.60 cents for beams and channels, 15-in. and under, angles and tees; tees, 1.65 cents; large beams and channels, 1.70 cents.

Steel bars, 1.40 cents, base, half extras.

Iron bars, 1.40 cents, delivered Pittsburg; 1.32 to 1.35 cents, Pittsburg, for western shipment; 1.50 cents, Chicago.

Sheets, 2.45 cents, net, for black and 3.50 cents, net, for galvanized, 28 gauge.

Tin plates, \$3.70 for 100-lb. cokes.

Wire nails, \$1.95, base; plain wire, 1.80 cents, base.

The Electric Furnace in the Steel Industry in Germany.

The abundance of articles on electric steel furnaces in the contemporary German engineering press is significant, especially as they are based on experience with electric steel making on a commercial scale. The two papers by Geilenkirchen and Osann (page 405 of this issue) give the experience of two German steel works, using the Heroult and the Roëchling-Rodenhauser furnaces, respectively. B. Osann (*Stahl und Eisen*, May 6) reports on the satisfactory operation of the Stassano process in Bonn (Mr. Stassano's article in our August issue). Another novelty is the operation of electric furnaces on three-phase systems, like Mr. Straube's steel hardening furnace (page 410 of this issue). B. Neumann reports in *Stahl und Eisen*, Aug. 12 and 19, on a three-phase Roëchling-Rodenhauser furnace in which some thousand tons of rails have been made and sold to German railways. We reserve a translation of this article for our next issue.

CORRESPONDENCE.

Steel Foundry Practice.

To the Editor of *Electrochemical and Metallurgical Industry*:

SIR:—I have written Mr. W. M. Carr, replying to his criticisms on my statements concerning steel foundry practice.

Mr. Wolff's latest word on this subject is so courteous, and his spirit so fair-minded, that I am sure it will now be patent to all steel-founders that he is not waging war on them, in a very proper effort to exploit the electric furnace.

GRANITE CITY, ILL.

R. A. BULL.

* * *

Electrochemical Processes for Central Stations.

To the Editor of *Electrochemical and Metallurgical Industry*:

SIR:—Your editorial in the September issue on the subject of "Electrochemical Processes for Equalizing Central Station Loads" opens up a subject that has for some time occupied the attention of progressive men in the two professions.

What you say is in the main, in my opinion, true, but there occur to me several objections or rather suggestions to your exposition of the question. It is to be hardly expected that central station men can sell power for a 20-hour day at less than 5 to 6 mills at their own switchboard, which means a considerably higher cost at the switchboard of the consumer. On the other hand, power can be produced at a coal mine or in the Western natural gas fields in large amounts for certainly less than one-half and possibly as low as one-third of these figures. In addition, power can be bought from different hydro-electric plants at an even lower price if in large amounts. In either case, the cost is such that it can be laid down as a fact that except in special instances, no electrochemical plant would care to use power at 6 mills with a considerable interval of idleness against a 24-hour use of power at 3 mills per kilwatt-hour at, we will say, Niagara Falls.

So it is my belief, that, save in special instances, where the cost of power is less than half the cost of total treatment, will industries yet to be born, start their little life in the more unfavorable environment.

But in industries using 150 to 300 kw where local conditions carry the balance to the other side, there should be a good field for the electric furnace in melting metals for casting or for refining waste products as well as in other ways. Anybody who can see what 100 kw-hours will do in a small electric crucible furnace can have a concrete example of its effectiveness in melting, welding and annealing metals.

Here, also, there is a snag. Any furnace that is to do rush work should be cheap and easily repaired. It should, of course, work with a tremendous amount of energy per cubic foot of active space. This will tend to increase the thermal and the commercial efficiency. As a general rule, people will not make any change in their plant if capital outlay is great. Furthermore, its special use will be found in small shops where a quick effective source of heat is needed *intermittently*. A host of such examples occur to my mind—such as small manufacturing jewelers and small repair shops. In this electricity will meet the competition of gas, with the numerous practical gas furnaces for just such uses already worked out and for sale at low figures.

It is useless to prophecy much, for I am neither a prophet nor a son of a prophet. But it is my belief that there will only be any considerable successful outlet for the surplus power of central stations, if the combined opinions of the electrochemist and the central station man realize these practical and commercial points and consider carefully the competition of gas in this direction as most formidable. Your journal will do a lasting and real service to the future of the central station by promoting the discussion of the question even with off-hand opinions such as this of mine.

NEW YORK CITY.

METALLURGICAL ENGINEER.

Electric Furnaces for the Manufacture of Calcium Carbide and Ferrosilicon.

Dr. WALTER CONRAD, of Vienna, presented an interesting paper on this subject at the last general meeting of the Verein Deutscher Eisenhüttenleute in Düsseldorf. We herewith give a translation, slightly abstracted, of the paper and discussion. The full text may be found in *Stahl und Eisen* of June 3 and 10. This paper is naturally restricted to an exposition of the industries in Europe.

The commercial connection between calcium carbide plants and ferrosilicon plants is due to the fact that when the over-worked calcium-carbide boom collapsed in Europe in the beginning of this century, many of the existing carbide plants endeavored to find a more profitable production for their furnaces and began to make ferrosilicon in furnaces which were originally intended for carbide.

The formula for calcium carbide manufacture is

$$\text{CaO} + 3\text{C} = \text{CaC}_2 + \text{CO},$$
 that for ferrosilicon manufacture is

$$\text{SiO}_2 + 2\text{C} = \text{Si} + 2\text{CO}.$$

Theoretically the production of 1000 kg calcium carbide requires 874 kg of caustic lime and 562 kg carbon. The production of 1000 kg silicon requires 2140 kg silica and 860 kg carbon; iron, added in any quantity, will alloy with the silicon to form ferrosilicon. In the carbide reaction 436 kg of carbon monoxide, in the ferrosilicon reaction 2000 kg are theoretically developed.

Aside from the similarity of the simple reaction equations, there are great differences between the two processes.

The calcium carbide process may be compared with a smelting process; at the high temperature of the furnace the calcium oxide becomes fluid and absorbs the carbon, forming a fluid bath of calcium carbide. On the other hand, the manufacture of ferrosilicon is a difficult reduction process. Fused quartz is not readily fluid; the fluid silicon which is formed has difficulty to pass through the sticky silica mass, especially in view of the low specific gravity of silicon. The process is facilitated by the addition of iron, the heavy iron drops running downward and carrying the silicon along.

In the carbide process the impurities are carried out of the furnace with the molten carbide. In the ferrosilicon process the impurities remain in the furnace and form a sticky slag high in silicon. It is impossible to use lime or other basic fluxes, because these would only increase the slag formation. The removal of the slag requires care; if the proper moment is missed, the furnace is filled with slag to an extent that tapping becomes impossible. It is then necessary to tear the whole furnace down and build it new.

In the beginning of the ferrosilicon industry serious mistakes were made in estimating the output. In the laboratory 4 kw-hours produced 1 kg of carbide yielding 300 to 310 liters acetylene. This corresponds to

6 kg per kw-day,
 4.4 kg per electric hp-day,
 4.0 kg per turbine hp-day.

If the year has 350 working days, this is equivalent to
 2.1 tons per kw-year,
 1.5 tons per electric hp-year,
 1.4 tons per turbine hp-year.

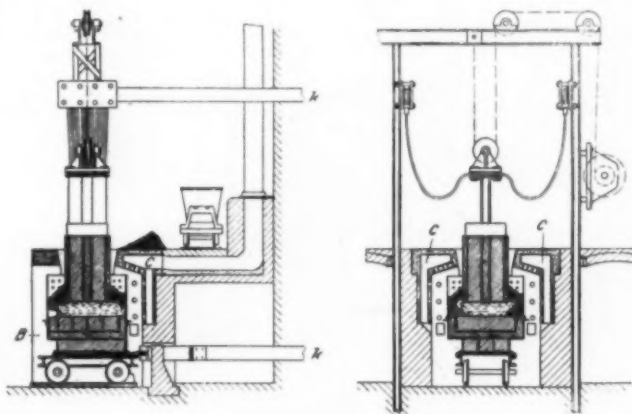
It was arbitrarily estimated that when operating on a large scale the output would be doubled. But, as a matter of fact, hardly two-thirds of the laboratory output was obtained. This was a bad disappointment.

The first furnaces, built by Gin and Leleux in Meran, by Schuckert in Jajce, Gampel and Hafslund, by Siemens & Halske in Lechbruck, by Bullier and others in France, were small crucibles on a carriage, as shown in Figs. 1 and 2. The bottom *B* of the crucible was one pole, while an electrode suspended in the crucible was the other pole, the connections to the external circuit being at *k*. The intention was to work continuously in these furnaces which were, therefore, provided with tap-holes.

A similar, but stationary, furnace was that of the Allgemeine Elek. Ges., the oldest type being shown in Fig. 3.

These oldest types of furnace offered many great difficulties on account of the dust evolved and the flames breaking out of the furnace. Tapping was very difficult, since around the walls of the hearth a layer of cold solid carbide formed of 10 to 20 cm thickness, which even when red hot, was as hard as good brick.

In the case of the movable furnaces on trucks, this difficulty was overcome by abandoning the method of tapping and remov-



FIGS. 1 AND 2.—OLDEST CARBIDE FURNACE AT MERAN (200 KW).

ing the carbide in form of a block. But this method also offered great inconveniences.

Important progress was made when the bottom of the furnace was no longer used as one electrode, two vertical electrodes being suspended from the top. This type, called "series furnace," is shown in Fig. 5. With this construction the output was increased by 20 per cent.

The advantage of this arrangement is that when the two electrodes are raised, the formed carbide remains no longer in circuit (while with the former arrangement it acted as a series resistance consuming energy).

In the older furnaces it was not possible to make larger blocks than 400 kg, while in the series furnace blocks of more than 1 ton could be produced. The loss of heat during cooling and the troubles attending the removal and cleaning of the carbide blocks remained, however, the same.

Those plants which used stationary furnaces had, of course, to devise means for properly tapping the furnace. While they have been finally successful in this respect, they have not been able to increase the output per unit of energy. Furnaces of this type are shown in Figs. 3 and 4. They are lined with carbon. The carbon bottom is one pole. It is directly in contact with the cast-iron foundation structure, which is made hollow to render artificial cooling possible.

The method of tapping with these furnaces was as follows: When a charge had been finished, no new material was added, but the supply of energy was continued with the result that one-fourth to one-third of the formed carbide was evaporated, dense fumes going off through the roof. At the same time the cold outside layer of carbide was melted to such an extent that through the tap-hole it became

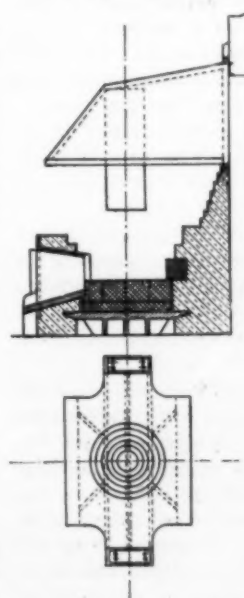


FIG. 3.—OLDEST CARBIDE FURNACE. ALLG. ELEK. GES. (200 KW.)

possible to perforate the carbide layer from the outside. For this purpose an iron rod, electrically connected with the upper vertical electrode, was pushed through the tap-hole into the carbide. The arc which formed fused both the iron rod and the solid crust of carbide.

It was recognized in 1900 that to make real progress it would be necessary to use larger furnaces. The first furnace of this

broader and broader until finally the current passes not only through the charge, but through the incandescent furnace walls. It is then no longer possible to concentrate the energy. For processes with intermittent operation (like carborundum) this does not matter, but continuous operation becomes impossible under such conditions.

The effective remedy is found in the layer of vapor around the electrodes.* That this layer is the real zone of reaction is

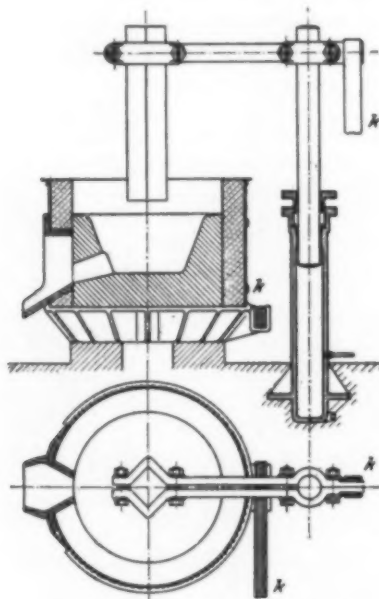


FIG. 4.—OLDEST MATREI FURNACE. (300 TO 500 KW.)

kind was that of Schuckert, of a capacity of 2000 kw, as shown in Figs. 6 and 7. The intention was to pass the current through the furnace in a longitudinal direction. Large blocks of carbon *b* were placed in the furnace so as to force the current into the desired path. These carbon blocks *b* were placed on blocks *a* of refractory insulating material. It was intended that the carbide should form at the terminal surface of the blocks *b* and should collect in the carbon hearths *c* below and flow off through the tap-holes *f*. However, this furnace was ill-fated; when it was started the furnace building was ignited by the exit gases and burned down.

According to our present knowledge of electric-furnace operation, the following principles must be fulfilled in the design of large furnaces for the manufacture of carbide and ferro-silicon.

First, the electrodes must not be in immediate contact with the charge; there must be a layer of vapor between electrode and charge, and this zone of vapor is the real zone of reaction. The importance of this condition will be recognized from the fact that at the high temperature of the furnace process all materials become conductors. At the high temperatures employed, the specific electric resistance of charcoal, quartz, lime and magnesite becomes a few ohms (per meter length and square centimeter cross-section). The conductivity is, therefore, pretty good. In a furnace in which the electrodes are in electrical contact with the charge and walls, the voltage will, therefore, decrease with increasing temperature. At the same time the cross-section through which the current passes becomes

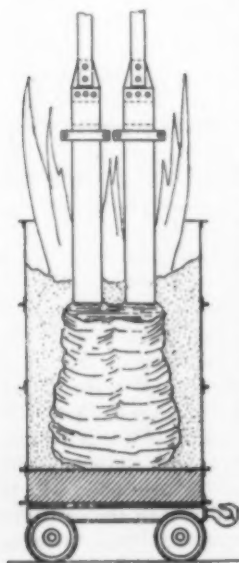
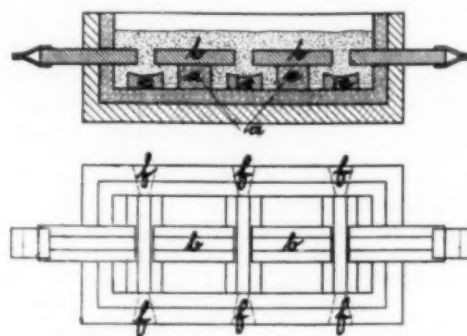


FIG. 5.—SERIES FURNACE. (450 KW.)

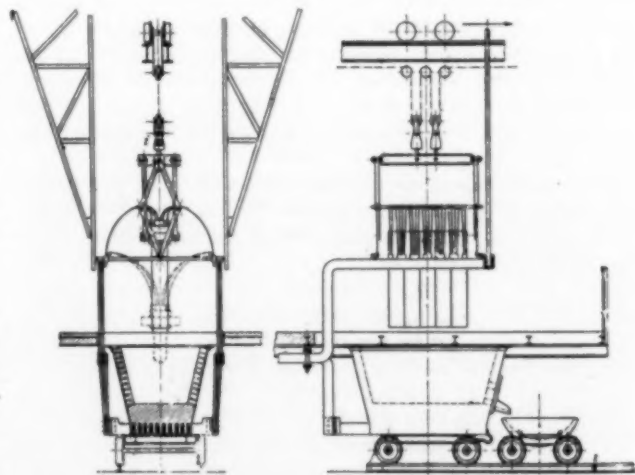
broader and broader until finally the current passes not only through the charge, but through the incandescent furnace walls. It is then no longer possible to concentrate the energy. For processes with intermittent operation (like carborundum) this does not matter, but continuous operation becomes impossible under such conditions.



FIGS. 6 AND 7.—SCHUCKERT FURNACE. (2000 KW.)

proven by electrical measurements during operation. The voltage drop is essentially within this layer. Right at the surface of this layer, and only there, the carbide is formed. All designs of furnaces in which the electrode presses on the charge or rests on parts of the wall (like the Schuckert furnace of Figs. 6 and 7) are faulty. The simplest suitable construction is the very first one used by Siemens and employing a vertical electrode suspended from the top into a crucible.

Secondly, the most suitable furnace lining is obtained by cooling and slagging the layer of molten charge next to the walls. This layer is less destructible than any brick. Further, the introduction of any impurity from the lining into the charge is thereby avoided. The walls are artificially cooled from the outside by air or surrounded by metal plates which radiate the heat. For carbide furnaces, cooling with water is dangerous, on account of the possibility of formation of acetylene. In ferro-silicon furnaces cooling with water is largely employed.



FIGS. 8 AND 9.—SWEDISH FURNACE FOR 400 TO 800 KWS

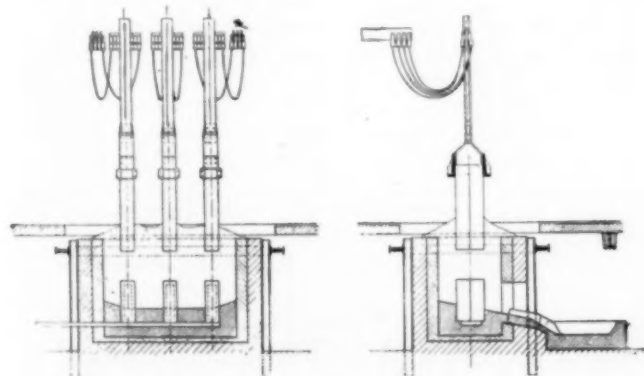
Thirdly, the bottom of the furnace should not be used as one terminal of the circuit. This third condition is, however, not universally recognized. In Sweden and Italy the bottom is still used as one terminal in carbide furnaces. The disadvantage is

*The author speaks of the "freibrennen der Elektroden," "free burning of the electrodes." He simply means that the electrodes when burning will produce a layer of vapor around their surfaces; this vapor zone prevents direct contact between electrode and charge, and in this zone the arc plays. When the arrangements are properly made, the electrodes will produce spontaneously this vapor zone.

the difficulty of getting a good contact between the iron foundation and the carbon bottom of the furnaces.

A very careful construction is illustrated in Figs. 8 and 9, showing a Swedish carbide furnace for 400 to 800 kw on a truck. A cast-steel grate is used as bottom, with a tar coal mass stamped in so as to make a good electrical contact. The side walls are made from sheet iron lined with a thin layer of a refractory material. The cooling system of the walls is perfect. The tap-hole is in one of the end walls; at this place the sheet-iron wall is strengthened by a cast-iron plate. This furnace is used exclusively for carbide manufacture. It would not be suitable for ferrosilicon, since the iron parts would be quickly destroyed by the spray from the outflowing metal. According to Dr. Conrad, the bottom is not used as a terminal in any modern ferrosilicon furnace.

The first attempts to make ferrosilicon in a furnace of several thousand horse-power capacity were made in the three-phase furnace shown in Figs. 10 and 11 ("the starting point of modern manufacture of ferrosilicon on a large scale"). It is a silica-brick furnace with steel girders, lined with firebrick. The bottom is made from stamped carbon in which is embedded a large iron plate, on which rest three electrode blocks rising above the furnace bath. They are arranged exactly below the three electrodes suspended from above.



FIGS. 10 AND 11.—THREE-PHASE FURNACE FOR 1200 KW.

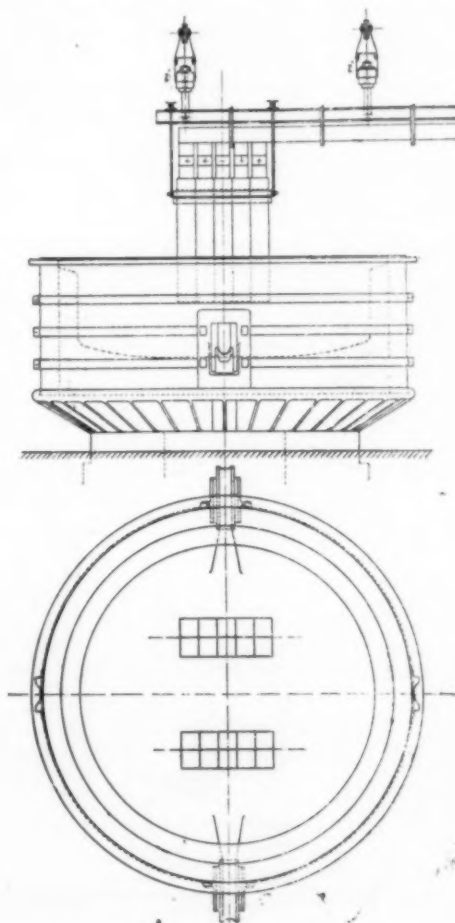
In the patent specification the lower electrode blocks were considered to be of great importance. It was expected that the ferrosilicon when formed there would flow off to a space filled with pieces of quartz. In this way the ferrosilicon would be quickly removed from the zone of the arc, so that evaporation would be avoided, and at the same time it was intended that the ferrosilicon should filter through the quartz pieces and that any carbon content in the ferrosilicon would be removed by the reaction between carbon and silica.

This hope was not fulfilled, however, in practice. The whole furnace content became mashy and sticky, and the lower layer of silica lost its granular structure, which would be required for filtering. The ferrosilicon would make its own way and would preferably collect around the tap-hole, where some hollow spaces had been left from the last tapping operation. This resulted in a strong hydrostatic pressure upon the front wall, which would buckle. Cracks formed and the ferrosilicon ran down between the vertical layers of the furnace wall into the foundation of the furnace.

This was facilitated by the fluidity and low melting point of the ferrosilicon. It resulted in the destruction of the furnace wall. Nothing but carbon can withstand the chemical attack of ferrosilicon. If molten ferrosilicon drops fall on iron, the latter melts and dissolves immediately. Alumina, lime and all silicates form a glassy slag. If ferrosilicon gets in contact with stamped concrete, it will attack it and progress slowly, but without fail.

Further progress was made with the construction of the direct-current 3000-kw furnace of Figs. 12 and 13, which is an

almost perfect design of the year 1905. The furnace chamber is made so large that the brickwork is removed from the zone of greatest heat and the walls of the smelting zone, which are formed from the material of the charge, sintering together. The furnace is lined inside with carbon. The carbon of the bottom rests immediately on an iron bottom plate, which is provided with ribs for cooling. A layer of firebrick separates the carbon lining of the side walls from the outer iron sheets, which are bound together so that they may be tightened or loosened.



FIGS. 12 AND 13.—DIRECT-CURRENT SERIES FURNACE. (3000 KW.)

This furnace was in operation for more than a year; when torn down it was found to be in perfect condition. In view of the great distance between the tap-hole and the zone of reaction, the wall to be pierced through at the moment of tapping, became so thick that steel rod and hammer would no longer suffice, the slag being very hard even at red heat, while the iron rod then softens.

It was, therefore, absolutely necessary to solve the problem of tapping with the arc. The details may be seen from Figs. 14 and 15, which show a furnace for 4000 kw to 6000 kw. Furnaces of this type have recently been put in operation in Norway and Austria.

A is the small tapping carriage. The end of a rod of 6-m length holds the pointed tapping electrode, which is supplied with current through the copper cable k. With this arrangement it is possible to melt a hole through a carbide or slag block of half a meter thickness in 20 minutes.

The furnace itself is made of firebrick and lined with carbon. A comparison of all the furnace designs shown in the above illustrations emphasizes their similarity and simplicity. "Aside from enlarging the size, no principal advance has been made in furnace design since Werner Siemens placed a small carbon rod in a graphite crucible." This is in marked contrast with the

infinite variety of furnaces designed on paper and described in patents.

Dr. Conrad urges that in examining patents on furnace construction, novelty should be considered of less importance than practicability. It should be proven that a certain construction can be carried out in practice, or has been carried out. Dr. Conrad thinks that all patents which have been granted should be declared void if their impracticability is afterwards proven.

Dr. Conrad then discusses at some length the different methods of making the connections between electrodes and the external circuit. He distinguishes between side connections (*zangenfassungen*) and head connections (*kopffassungen*). Side connections press against the sides of the electrodes so that a displacement of the electrode in the longitudinal direction is rendered possible. A side connection much used, is shown in Fig. 4; it consists of two water-cooled halves which grasp the electrode. As is well known, Héroult also used a side connection. With side connections any waste of electrodes may be avoided, if a new electrode is connected to the old one, as shown in Fig. 18. This makes no difficulty with soft electrode material since the two electrode pieces burn together immediately.

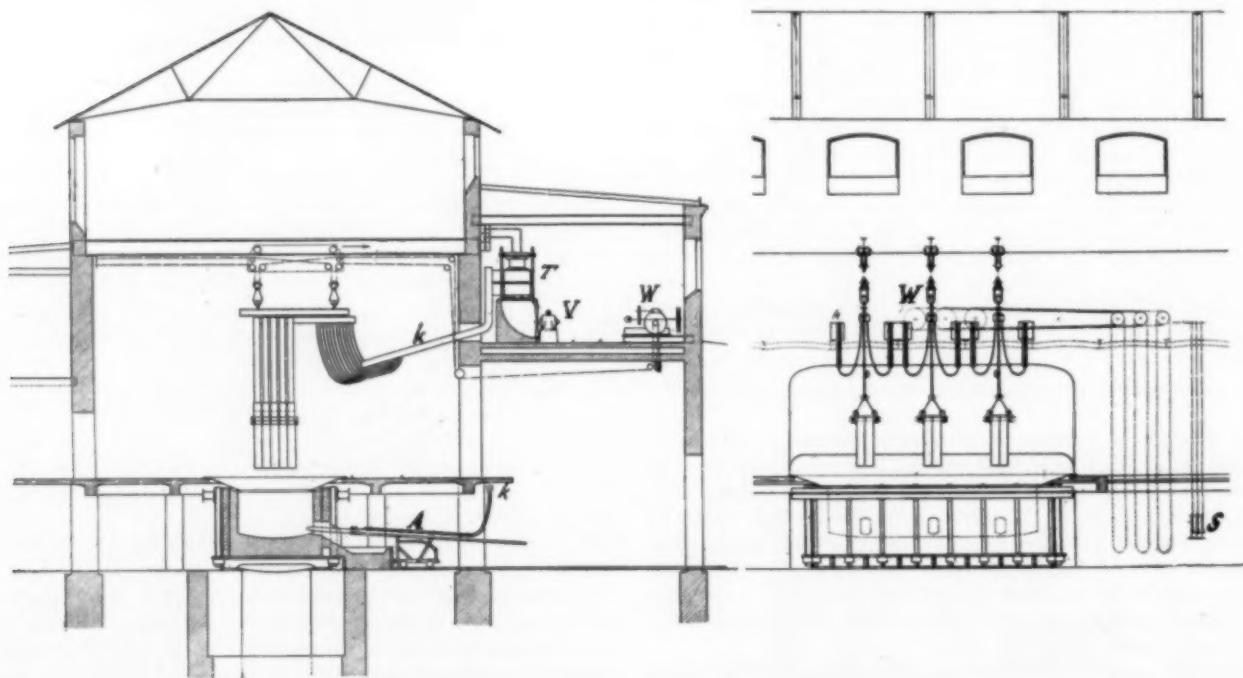
Side connections have the disadvantage that several electrodes cannot be assembled to form one package, while this is possible with head connections.

possible through the iron plate, so that at the lower rim of the latter the current density is a maximum.

Since one of the chief items of expense of electric furnaces is the copper for the conductors, it is important to make the conductors as short as possible. This has the further advantage of reducing the resistance and reactance of the conductors, thus diminishing the ohmic losses and phase difference.

Figs. 14 and 15 show an arrangement in which the total length of conductors from the secondary terminals of the transformers to the electrodes is only 13 m (43 ft.). In general it is difficult to place the transformers near the furnace without subjecting them to dust and heat, and without encroaching on the space around the furnace which is needed by the workmen. The best solution is to place the transformer on a high level, as shown in Fig. 14, where *T* are the transformers with the ventilators *V* for air-cooling. *W* is the motor for raising the electrodes and *S* the controller.

The difficulties are much greater when the furnace is supplied with energy not from a transformer, but directly from a generator. This arrangement must necessarily be used with direct current. For this reason alone, alternating current is preferable to direct current. In plants with which Dr. Conrad has been connected, the output per unit of energy was the same with direct-current and alternating-current operation and the carbide



FIGS. 14 AND 15.—THREE-PHASE FURNACE FOR 4000 TO 6000 KW.

The oldest and poorest head connection is the swallow-tail connection (Fig. 16). Its weak point is the final cracking off of the swallow-tail, as the result of tightening the screws. The construction of Fig. 17, in which the electrode is held by friction between two lateral plates, is better.

The head connection has undergone a peculiar development in Sweden, as shown in Figs. 20 and 21. The contact plates *a* are pressed against the electrodes by means of the wedges *b*. The latter are held in place by the longitudinal screws *c*, and these are prevented from lateral displacement by a series of cramps *d*.

Technically the most perfect head connection is that shown in Fig. 19, which has been developed in Italian plants. The water-cooled contact plate is pressed against the end surface of the electrode. Among all connections illustrated this is the only one which has a uniform current density all over the contact surface. With all other connections the current passes as far as

was of equal quality. On the other hand, ferrosilicon made in alternating-current furnaces is purer, because in direct-current furnaces electrolysis of the charge reduces calcium, aluminium and other metals which thereby get into the ferrosilicon.

For the fixed portion of the secondary circuit it is preferable to use copper ribbon of 150 mm to 300 mm breadth and 7 mm to 15 mm thickness. To reduce the self-induction, the well-known method of transposition of the conductors may be used. This arrangement is used with the furnace of Figs. 8 and 9. In this case the two conductors of opposite sign come together from the transformer room and separate into a conductor going upward and another one leading downward right at the furnace.

The conductor leading downward is connected by means of copper pole-shoe directly to the cast-steel grate of the furnace bottom. The conductor leading upward is connected to a flexible copper cable leading to the electrode. The details may be seen from Figs. 20 and 21.

The flexible cables are supported by the rods *e*, which are held by shears in such a way that when the electrodes are raised or lowered the rods *e* are raised or lowered only half the distance.

Though the arrangement is ingenious it has the disadvantage that the bending of the cables and their rubbing against the supporting rods causes excessive wear and tear. A further disadvantage is that the flexible copper cables, which are made of wires of 0.7 mm thickness, soon oxidize and burn through when exposed to the heat of the furnace and the furnace gases. It is, therefore, preferable to use nothing but copper bars above the furnace and to place the flexible part of the connection outside of the furnace. This arrangement is used in Figs. 12, 13, 14 and 15.

In order to prevent a serious reduction of the power factor it is important to avoid the induction of alternating currents in closed iron circuits. The Swedish furnaces of Figs. 8 and 9 suffer from this trouble, while the three-phase furnaces 10 and 11, 14 and 15 are almost free from it. Even if closed iron-circuits are carefully avoided, eddy currents will be induced in practically every piece of metal in the furnace room. This may involve some danger, for instance, when as a result of eddy currents the chains holding the electrodes become red hot and loose their strength.

With the old small furnaces the supply of electrical energy to the furnaces reacted in a troublesome way on the lighting network on account of the sudden variations in the furnace load. Variations of current and voltage by 10 per cent were usual. On the other hand, the large modern furnaces have a load as regular as a constant-load motor of equal capacity. Regulation of the current is necessary only during tapping and during changing of the electrodes. While it may not be advisable to operate electric furnaces in parallel with the lighting network of a city, there is no trouble whatever in operating the furnaces in parallel with the lighting and power network of the works. The furnace itself is absolutely indifferent to any variation of voltage or speed of the motors.

The raw materials of carbide manufacture are burnt lime or limestone, and coke, charcoal or anthracite; those of ferrosilicon manufacture are quartz, charcoal or anthracite, and iron. If these raw materials contain too many impurities, the carbide produced will yield less acetylene per pound of carbide; on the other hand, ferrosilicon manufacture becomes impossible with too many impurities in the raw material.

The most serious impurity for both carbide and ferrosilicon manufacture is phosphorus, since in the decomposition of the products phosphureted hydrogen is produced which may lead to explosions and poisonings. For this reason specifications for carbide contain a requirement as to the maximum content of phosphureted hydrogen in acetylene. European railways and steamship companies have also recently made more stringent regulations on the transportation of ferrosilicon.

It is, therefore, important to avoid raw materials containing phosphorus, and for this reason especially coke and cast iron containing phosphorus cannot be used.

While in the early days of the industry much attention was paid to careful grinding of the raw materials, it is now usual to use charcoal unbroken, lime, quartz and coke reduced to pieces not less than 4 cm. In large furnaces pieces as big as a fist or a head may be successfully used.

"Of greatest importance for the financial result is the power consumption. In well-managed plants the production of 1 kg of carbide requires 4 kw-hours; that of 1 kg of silicon, 12 kw-hours, so that 1 kw-day will produce 6 kg of packed carbide and 4 kg of ferrosilicon of 50 per cent.

"The water-power plants of the Alps and Norway operate with a power cost of 0.1 to 0.25 cent per kw-hour, so that the cost of power is \$4 to \$10 per ton of carbide and \$6 to \$15 per ton of 50 per cent ferrosilicon. But the location of the large water-power plants is often unfavorable for the supply of the raw materials and for the marketing of the products.

"Steam plants operating near the market have the advantage of lower freight expenses." Under average European conditions this advantage is figured out in dollars and cents by Dr. Conrad as follows: "For the production of one ton of carbide there are required two tons of raw materials. For the production of one ton of 50 per cent ferrosilicon there are required 2.7 tons raw materials. Each ton of product, therefore, involves freight for three to four tons to and from the works, costing at least \$2.50 per ton. Hence, a favorably-situated steam plant saves from \$7.50 to \$10 in shipping expenses per ton of finished product, compared with an unfavorably-situated water-power plant. By this amount the steam power may be more expensive than the water power without increasing the total cost. This gives a difference of 0.175 cent per kw-hour." In the case of the carbide industry it is also to be taken into account that when the factory is located near the consumers, one-half or two-thirds of the cans are returned and may be used again, which means another saving.

As long as the output of carbide and ferrosilicon per unit of electrical energy was low, the power cost was so important that competition of steam plants with water-power plants was out of the question. But with the gradual improvements of the processes the efficiency has been raised to such an extent that both manufactures may now be successfully carried out in coal regions and metallurgical districts, especially if steam turbines are employed and if cheap and good raw materials are available. As a matter of fact, carbide plants have already been erected in European coal districts.

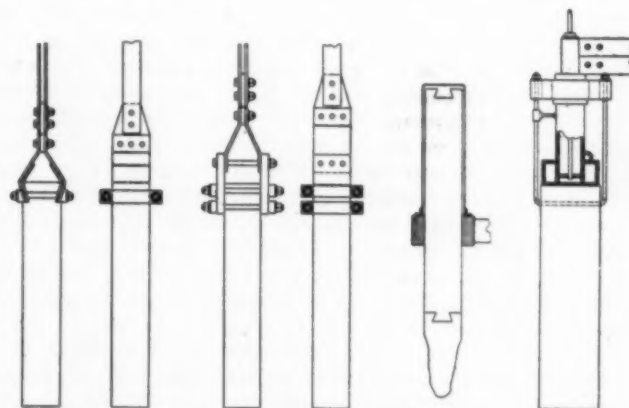


FIG. 16.—SWALLOW-TAIL CONNECTION. FIG. 17.—SIDE PLATES.
FIG. 18.—ATTACHMENT OF ONE ELECTRODE TO ANOTHER.
FIG. 19.—ITALIAN HEAD CONNECTION.

The market for calcium carbide is steadily growing, not only for acetylene lighting plants, but for the use of acetylene for welding, heating and cooking, and for chemical purposes. There is also good prospect that the manufacture of calcium cyanamide will soon consume important quantities of carbide. For lighting in mines acetylene is ideal and should be generally used.

The ferrosilicon market is just at present in a bad condition as a result of the crisis in the iron and steel industry.

Dr. Conrad appears to look favorably on the erection of ferrosilicon plants by the steel companies themselves. He thinks the present crisis is favorable to such work. He also thinks that the ferrosilicon industry would profit thereby. It has been developed in the past by chemists and mechanical engineers. The co-operation of steel metallurgists would necessarily bring good results.

Dr. Conrad's paper elicited an extended discussion which was opened by Geheimrat Prof. WEDDING, who spoke here for the last time before his death. He asked several questions: Why does the steel industry not use so large electric furnaces as the carbide industry? Why are induction furnaces not used in the carbide industry? The Héroult furnace is essentially an arc

furnace. Even if the ends of the electrodes are within the upper layer of the slag there will be a layer of gas around them through which the arc plays from the electrode to the slag, as described in Dr. Conrad's paper for calcium carbide. In the Héroult furnace the arc heats the slag from above, and this is an advantage over the induction furnace.

Dr. CONRAD replied that in the steel industry a temperature of 2000° is required, which can be easily obtained in the induction furnace. On the other hand, formation of carbide and fusion of quartz require a much higher temperature, say, 3000° C. This cannot be produced in the induction furnace. The reason is that at this temperature no lasting and non-conductive furnace lining is available. When in the induction furnace the temperature is raised more and more, the furnace lining begins to conduct and the current is no longer restricted to its proper path. Formation of carbide and reduction of silica occurs only at highest current density within the zone of the arc. There is nothing like this in the induction furnace. In the induction furnace no temperature like that of the arc can be produced.

In the Stassano furnace the arc is formed a few decimeters above the bath in the free upper space of the furnace and the heat is thereby radiated from above in the same way as is the case in the open-hearth furnace. On the other hand, in the Héroult furnace the source of heat is in the slag itself directly above the steel bath. In this way it must be possible to get a higher temperature of reaction. In the Héroult furnace the liquid slag is the top layer of the contents of the furnace. In the carbide furnace and in the ferrosilicon furnace the fused bath is covered with raw material which is being preheated and only partly softened or fused. The electrodes pass through this raw material without giving off any appreciable amount of current to the surrounding material. This material prevents the electrodes from burning off and also protects the upper parts of the brickwork of the furnace from the intensive heat of the arc.

Dr. GEILENKIRCHEN spoke of results obtained in the steel works of Richard Lindenberg, in Remscheid, with the Héroult furnace. The danger that parts of the carbon electrodes might break off and fall into the steel bath exists only on paper. The terminals of the electrodes are not within the slag, but above the surface of the same, and the length of the arc is regulated by the mechanism raising and lowering the electrodes. Since the electrodes are vertical they themselves protect the upper part of the furnace from the heat of the arc. This is an advantage over the Stassano furnace in which the electrodes are not vertical.

Mr. B. KUTCHE spoke of the results obtained in the Bonner Fraeser Fabrik with the Stassano furnace during the last five months. This furnace consumes 800 kw-hours for melting 1000 kg of soft wrought iron, and from this the speaker calculates a thermal efficiency of 88 per cent. As this is very high, an increase of the furnace would only diminish the radiation losses, while with increase of size it would become more and more difficult to maintain the electric losses and the heat loss due to the cooling of the electrodes within proper limits. For this reason there is no advantage in increasing the furnace beyond a certain size. In the Stassano furnace the electrodes are not horizontal, but inclined downward. The arc plays downward toward the slag on the steel bath.

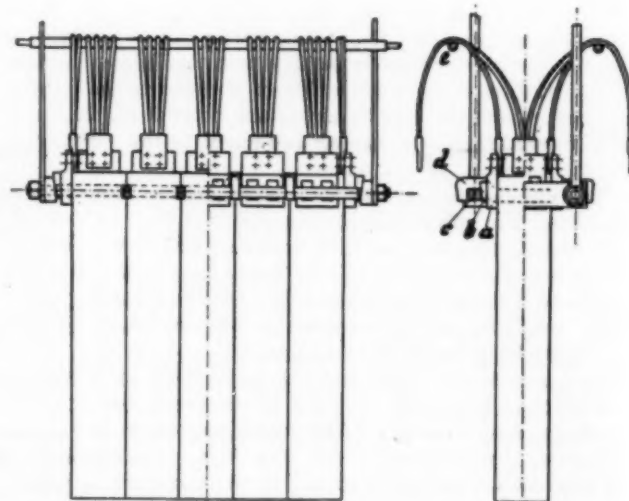
In reply to Prof. Wedding's question why the steel industry does not use as big furnaces as the carbide and ferrosilicon industries, Mr. Kutsche pointed out that the production of one ton of ferrosilicon requires 25 times the electric energy necessary for refining a ton of liquid steel. While the carbide industry uses furnaces of 6000 kw, an electric-steel furnace of 6000 kw would contain charges of 50 to 60 tons. There is not yet a commercial demand for such large quantities of steel of high quantity. Further, as explained before, the smaller electric furnaces are quite satisfactory.

Prof. EICHHOFF emphasized that Héroult never had the intention to heat the steel bath by the Joulean heat of the slag alone. The Héroult furnace is practically an arc furnace. The

resistance of the slag and bath produces only a few per cent of the total heat. He does not think it is possible to have an efficiency of 90 per cent in an electric steel furnace. There are always losses due to radiation and other causes.

According to Prof. Eichhoff if the thermochemical calculation is made, it is found that in a 1000-kg furnace less than 50 per cent of the calories supplied to the furnace are utilized. Small electric furnaces have hardly a higher efficiency than 50 per cent. When the size is gradually increased the efficiency may be increased to 70 per cent, or even 75 per cent, because the volume increases more quickly than the surface. In his practical experience he found that by increasing the size of furnace from a 1500-kg to a 3000-kg furnace the consumption of energy was increased by 10 per cent only. The consumption of energy per ton of steel increases considerably with the size of furnace. Furnaces for 15 tons are just as reliable and safe as smaller furnaces for 2000 or 5000 kg.

Prof. Eichhoff said the prevailing opinion was wrong that electric furnaces were suitable only for producing high-quality steels. The cost of production has been reduced so much that in a 5-ton furnace the poorest raw materials may be used to make steel of best quality with 200 kw-hours per ton of steel. And if it is not intended to produce steel of highest purity in large furnaces, it will be possible to reduce the energy consumption to 150 or even 120 kw-hours per ton of steel. Under these circumstances the cost of electric energy is insignificant in view of the higher quality of the steel produced. Such steel will be used for many purposes, even rails.



FIGS. 20 AND 21.—CONNECTION FOR FURNACE IN SWEDISH PLANT.

Mr. VOGEL called attention to the fact that ferrosilicon is not only used in the steel industry, but is also used as a raw material for making apparatus, pipes, etc., for chemical works, since they resist successfully the attack of acids of any kind (see the paper by A. Jouvé on "Metillure" alloys in our August issue, page 321). Ferrosilicon containing 75 to 80 per cent of silicon is unattackable by acids. The problem is to make this alloy on a large scale and bring it into the desired forms. The success so far obtained is quite promising.

Dr. O. WEIL pointed out that the production of high-percentage ferrosilicon or silicon with a purity of 90 to 95 per cent should bring good financial results. He referred to the production and uses of calcium silicide recently patented by Dr. Hans Goldschmidt for purification of metals and especially steel. (See the article of Dr. Goldschmidt in our June issue, page 244). A very large amount of aluminium is used every year in the steel industry for just that purpose for which calcium silicide is even more suitable. If only a part of this aluminium is replaced by calcium silicide there would be a large demand for silicon.

On Methods of Obtaining Cooling Curves

By G. K. BURGESS.

(Concluded from page 371.)

Direct and Inverse Rate Curves.

V. θ vs $d\theta/dt$.—In many problems it is of interest to measure the speed of the transformations under observation. This may be done by determining directly the rate of change of temperature of the sample in terms of its temperature. Le Chatelier²⁴ used this method in 1887 in his study of the properties of clays.

He was also the first to employ a photographic apparatus for the recording of cooling or heating curve data, using an arrangement in which the plate remained stationary. The sparks from an induction coil were made to pass at intervals of two seconds before a slit and gave upon the plate, after reflection from the galvanometer mirror, images of the slit whose spacing was a measure of the speed of heating, which in his experiments was about 2° C. per second.

Another method of recording the rate of heating or cooling in terms of the temperature has been devised by Dejean.²⁵ The new feature of this method is the use of an induction galvanometer or relay which may be inserted in the circuit of the more sensitive galvanometer G_1 of the Saladin system (Fig. 8). The principle of the apparatus is shown in Fig. 9. The induction relay is a modified d'Arsonval galvanometer having an electromagnet and a movable coil, the latter consisting

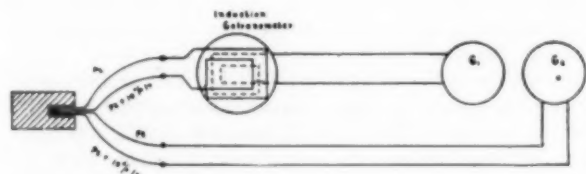


FIG. 9.—DEJEAN METHOD.

of two distinct insulated windings, one of which is connected to a thermocouple.

Heating or cooling one junction of this couple causes the coil to be deflected and its motion in the field of the electromagnet induces an e.m.f. in the second winding of the coil which is proportional to its angular speed and hence to the rate of change of e.m.f. of the couple, or approximately to the rate of cooling or heating, i. e., to $d\theta/dt$.

The induced e.m.f. is measured by joining this winding to the sensitive galvanometer G_1 . The galvanometer deflection passes through a minimum when the heating or cooling passes through a minimum, that is, for a region in which there is an absorption or evolution of heat. A second thermocouple in series with the other galvanometer G_2 of the Saladin system gives the temperature of the sample.

We have, therefore, on the plate P (Fig. 8), when the record is taken photographically, the temperatures as abscissae and the rate of cooling $d\theta/dt$ as ordinates, as shown in Plate I, Fig. V.

Dejean has used this method in the study of steels and has also investigated with it the copper-cuprous oxide system. The transition temperatures are very sharply marked. If desired, direct reading may be substituted for the photographic recording, with an increase in precision. This method is evidently a perfectly general one for recording the rate of change of e.m.f. (de/dt).

For neither Le Chatelier's nor Dejean's arrangement can differences in the rate of heating or cooling due to the substance itself be distinguished from those due to external causes, since no neutral piece is used.

VI. θ vs $dt/d\theta$.—Among the methods adapted for slow cooling, we shall mention last one of the earliest which was used to

throw into prominence the abnormalities of a cooling curve, namely, the *inverse rate method*, which was employed as early as 1886 by Osmond²⁶ in his classic researches in metallurgy. It consists in noting the intervals of time required for a substance to cool by equal decrements of temperature and plotting this quantity ($dt/d\theta$) in terms of the temperature. (See Plate I, Fig. VI.)

Osmond thus describes his method: "The time taken by the thermometer during the heating or cooling of the sample to rise or fall one division of the scale (1 mm) was registered by means of a Morse telegraph ribbon, or on a rotating cylinder turned by a small electric motor. . . . A halt of the thermometer is transcribed as a cusp and a slowing down by a swell of the curve, whose area is proportional to the quantity of heat set free."

But one thermocouple is needed and no neutral piece is used, so that the apparatus is the same as required for a θ vs t curve, I, although it is necessary, if work of precision is to be undertaken, to record very exactly by means of a chronograph and key the intervals of time (Δt) required to pass over a given number of degrees ($\Delta\theta$), say 5° C. or 10° C. intervals.²⁷

The method, however, cannot readily be made automatically recording for the variables θ and $dt/d\theta$ in terms of each other,

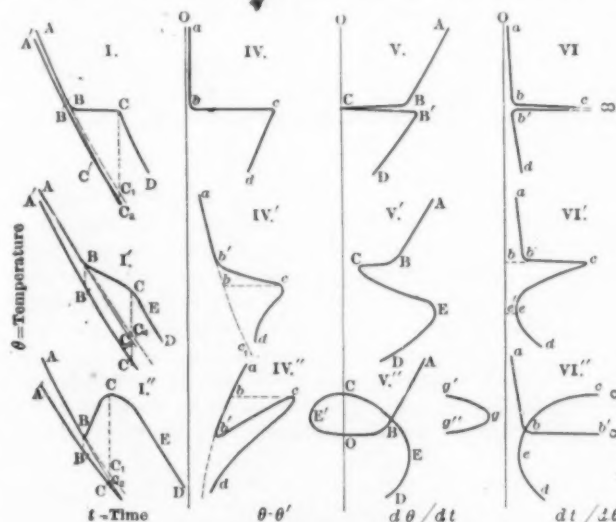


PLATE I.—TYPES OF COOLING CURVES.

and, therefore, requires the active presence of the observer. It has the same disadvantage as method II, in that the precision of a difference in temperature ($\theta - \theta'$ or $\Delta\theta$) can be made no greater than that of the temperature θ . The inverse rate method is perhaps best considered as one for interpreting and plotting the θ vs t data in such a way as to emphasize its irregularities and so the more readily permit the detection of any critical regions.

Rapid Cooling.

None of the experimental arrangements so far described is adapted for measuring the very rapid cooling, i. e., several hundred degrees in a few seconds, met with in quenching or chilling.

Le Chatelier,²⁸ in an investigation of the quenching of small samples of steel and the effect of various baths, made use of a galvanometer having a period of 0.2 seconds and a resistance of 7 ohms, whose deflections were recorded on a photographic plate moving vertically at a speed of 3 mm per second. A half second's pendulum vibrating across the path of the beam of light, from a Nernst glower as source, gave a measure of the time. He succeeded in recording satisfactorily temperature in-

²⁴F. Osmond, *Comptes Rendus* (Paris), 103, p. 743, p. 1122; 1886. 104, p. 985; 1887. *Annales des Mines*, 14, p. 1; July, 1888.

²⁵This method is well illustrated by F. Wüst, *Metallurgie*, 3, p. 1; 1906.

²⁶H. Le Chatelier, *Rev. de Metallurgie*, 1, p. 473; 1904.

²⁷H. Le Chatelier, *Comptes Rendus* (Paris), 104, p. 1443; 1887.

²⁸P. Dejean, *Rev. de Metallurgie*, 2, p. 701; 1905. 3, p. 149; 1906.

tervals of 700° C. in six seconds, using as samples cylinders 18 mm on a side.

It would be desirable to increase the precision and sensitivity of this method, which might be done, as Le Chatelier himself suggests, by using an oscillograph arrangement, or a string galvanometer, such as Einthoven's, in which the displacements of a silvered quartz fiber of high resistance in an intense magnetic field are measured photographically.

Characteristics of Cooling Curves.

In conclusion, let us consider briefly the forms that the different cooling curves may take and their approximate interpretation, for three typical kinds of transformation:

- The substance remains at a constant temperature throughout the transformation.
- The substance cools at a reduced rate, which may or may not be constant over a portion of the transformation.
- The substance undergoes an increase in temperature during the first part of the transformation.

An approximation to the first case, that of a strictly isothermal transformation, is met with in the freezing of chemically pure substances of sufficient thermal conductivity which do not undercool appreciably; in the formation of eutectics, and occasionally in other transformations. The second case is perhaps the most common; and the third is represented by the phenomena of recalescence and of undercooling preceding crystallization.

In the case of an isothermal transformation (a), heat is generated at the same rate that it is lost by radiation, convection and conduction, or, considering the phenomena as confined to the sample alone:

$$dQ/dt = Ms \, d\theta/dt \quad (a)$$

where M is the mass and s the specific heat of the body supposed constant during the transformation, dQ/dt the rate of generation of heat, and $d\theta/dt$ the rate of cooling the body would have, when passing through the temperature of the transformation, if there were no transformation. The heat Q generated in such a transformation lasting a finite time Δt , is, therefore:

$$Q = Ms \, \Delta t \, d\theta/dt \quad (b)$$

in which $\Delta t \, d\theta/dt$ is a measure of the fall of temperature, $\Delta\theta$ the substance, would undergo if there were no evolution of heat during the time Δt , that is, during the transformation, whence:

$$Q = Ms \, \Delta\theta \quad (c)$$

In the case of the transformation (b) we have

$$dQ/dt < Ms \, d\theta/dt$$

and for the transformation (c)

$$dQ/dt > Ms \, d\theta/dt.$$

In Plate I are illustrated these three types of transformation as given by the following cooling curves:

- θ vs t Temperature-time.
- θ vs $\theta - \theta'$ Differential.
- θ vs $d\theta/dt$ Temperature-rate.
- θ vs $dt/d\theta$ Inverse rate.

The first horizontal line of figures refers to case (a), the second line to (b), and the third line to (c). For all of the curves the ordinates are temperatures; and the corresponding parts of the several curves are indicated by the same letters. The vertical lines o , o' represent the zero of abscissae for each group of curves.

In the case of the temperature-time curves, Figs. I, I', I'', they are drawn for an accompanying neutral piece, A'B'C', as well as for the sample under study, ABCD. In I the sample and neutral are cooling at the same rate, while in I' and I'' they are cooling at different rates. In each figure the point C_1 indicates the temperature that would have been reached by the sample if there had been no transformation. C_1 may be considered as practically coinciding with C_2 , the temperature that would have been reached if the sample had continued to cool at the same rate as at B, the beginning of the transformation.

For each of these transformations (a), (b) and (c), as represented by the curves I, I', I'', the heat evolved is approximately proportional to $\Delta\theta \pm CC_1 = CC_2$, or the maximum dif-

ference in temperature produced by the phenomenon. It is to be noticed that in general the rate of cooling just to right of C will be greater than that just to the left of B, on account of the presence of the furnace; for the furnace walls, to which the heat is being lost, have continued to cool during the time BC. Even if the furnace were at a constant temperature, the rates at B and C might still be different due to the difference in specific heats and in emissivities of the substance before and after the transformation. The end of a transformation is always marked by a point of inflexion, as shown at E (Figs. I', I'').

From the temperature-time curve, therefore, we may determine the temperatures of beginning and ending of a transformation, its duration, an approximate measure of the heat evolved by the transformation, as well as the rate of cooling, and, therefore, of transformation, at any instant. The interpretation of the variations in these factors forms the basis of thermal analysis, which has begun to be so productive in the determination of the constitution of alloys and chemical compounds.²⁷

Although the forms of the curves representing the various methods are those corresponding to what is actually obtained from a sample cooling inside a furnace, yet it should be noted that the equations representing the evolution of heat are written in a form that practically neglects the influence of the furnace.

A complete discussion of the cooling within a furnace of a substance possessing transformation points would be more complicated than contemplated by this paper, requiring a knowledge of the law of cooling of the furnace and that of the interchange of heat between the sample and the furnace, the latter depending on their relative heat capacities and conductivities, the emissivity of the sample and the distribution of temperature within the furnace.

If small quantities of heat are involved in a transformation, the simplest assumptions that can be made are that at each instant the sample is losing heat to the furnace at a rate proportional to their difference in temperature, and that the parts of the furnace receiving this heat are all at the same temperature throughout at any instant. On this basis, the quantity of heat Q , lost by the sample during a transformation, as interpreted by the θ vs t curve, would be more nearly proportional to CC_1 than CC_2 .

The practical conditions of cooling, however, are in general somewhere between the two extremes of the sample cooling independently of the furnace as required by our equations, and within the simplified furnace above described; so that CC_1 may be considered a minimum measure of the heat evolved, the actual measure of this quantity varying with every different experimental arrangement.

In what follows, the limitations just discussed, concerning the measurement of the heat evolved during a transformation, are assumed to apply to each of the types of cooling curve.

Figs. IV, IV' and IV'' give the forms of the curves traced when the difference in temperature ($\theta - \theta'$) between the sample and the neutral piece of approximately the same thermal capacity is plotted in terms of the temperature (θ) of the sample. In Fig. IV the line bc , since it is the approximate equivalent of $CC_1 = \Delta\theta$ of Fig. I, may be taken as a measure of the heat evolved during the transformation.

If the cooling curves of the sample and of the neutral are not parallel, as shown in Figs. I' and I'', it is necessary, in estimating the heat evolved from the difference curve $ab'cd$ (Figs. IV' and IV'') to take into account the variations in $\theta - \theta'$ during the transformation. This change in $\theta - \theta'$ is given by $BB' - C_1C'$ (Figs. I', I'').

Furthermore, successive differential curves for the same sample are comparable only when the sample and neutral are

²⁷ The principles of thermal analysis as based on the θ vs t curve are quite fully described in the following papers by Tammann: *Zs. Anorg. Chem.*, 37, p. 303; 1903. 45, p. 24; 1905. 47, p. 289; 1905, a résumé of which is given by Portevin in *Rev. de Metallurgie*, 4, p. 970; 1907. See also Bancroft, *Jl. Phys. Chem.*, 6, p. 178; 1902. Shepard, *ibid.*, 8, p. 92; 1904. *Iron and Steel Mag.*, 8, p. 322; 1904. and Bakhuys Roozboom, *Die Heterogenen Gleichgewichte*, 1901.

cooled in the different experiments so as to always maintain the same temperature-time relation over a given range. When this is the case, bc (IV' and IV'') is still an approximate measure of the heat generated.

It can be shown that, except for horizontal tangents, the points of inflexion E of the θ vs t curves do not correspond to points of inflexion at the same temperatures on the differential curves, hence the end of a transformation cannot be determined from the latter. If equal time intervals are marked on the differential curve, the rate of cooling or of transformation over an interval Δt may be obtained by finding the value of $\Delta\theta/\Delta t$.

Although, as we have seen, the differential method may be made more sensitive and certain than the direct method, yet, from the above, it is evident that it furnishes a less complete basis for the interpretation of the physico-chemical phenomena involved in the indicated transformations.

Figs. V, V', V'' represent the temperature-rate curves (θ vs $d\theta/dt$), and Figs. VI, VI', VI'' the inverse-rate curves (θ vs $dt/d\theta$). The two types may be considered as reciprocals of each other. Comparing them with the θ vs t curves (Figs. I, I', I'') it is seen that a sharp break in the latter corresponds to a perpendicular to the temperature axis for both the former; and that for an isothermal transformation, $d\theta/dt$ becomes zero at C and $dt/d\theta$ infinite at c. When the θ vs t curve is convex to the θ axis, the $d\theta/dt$ curve is concave and the $dt/d\theta$ curve convex. Both curves give negative values (OE'C, Fig. V'', and g'gg'', Fig. VI'') for a region of recalescence.

The end of a transformation, corresponding to a point of inflexion E on the θ vs t curve, is sharply indicated (E, e) on both these rate curves by the tangent becoming parallel to the θ axis and the curve having a maximum or minimum abscissa. For any region of cooling at a constant rate, the tangent remains parallel to the θ axis during this interval.

From neither of the rate curves can the relative amounts of heat evolved during a transformation be readily computed for the different kinds of transformation. The area of the inverse-rate curve, however (Fig. VI'), taken between the limits b', c', is proportional to Δt , or to $Q/d\theta/dt$ (see equation β), that is, to the quantity of heat generated divided by the rate of cooling.*

If the rates of cooling at the beginning of two transformations are equal, then the areas, taken as above for the inverse-rate curves (Fig. VI'), become an approximate measure of the heat generated. This condition, however, is rarely realized in practice. An examination of Fig. VI'' shows the practical impossibility of constructing any instrument other than one using an optical system for recording the complete inverse rate curve.

We see, therefore, that both these rate curves mark the limits of a transformation more sharply than either the temperature-time or differential curves, and, in general, show greater changes in form for slight heat changes, but the rate curves do not, in general, give a simple measure of the heat evolved, nor is a neutral piece used to eliminate extraneous heat fluctuations.

A comparison of the properties of these various cooling curves indicates that the one from which the most comprehensive view of a transformation can be obtained is the simple temperature-time curve (I) when this method is made sufficiently sensitive; the one giving the least information is the temperature-rate curve (V); and those which cannot readily be recorded directly by any form of instrument yet devised are the inverse-rate curve (VI) and the derived differential curve (IVa); while the one that can be made the most sensitive and certain is the differential curve (IV).

The analytical discussion, therefore, leads to the same result as the examination of the experimental methods, namely, that for great range, combined with greatest sensitiveness, the most certain and complete data may be obtained by combining the temperature-time observations with those obtained by the differential method.

BUREAU OF STANDARDS, WASHINGTON, D. C.

* The area b' b' c' c' = $t_2 - t_1 = \Delta t$, or the time occupied in falling a temperature $\Delta\theta$.

Removal of Sulphur in Electric Steel Furnaces.

The removal of sulphur in electric furnaces for steel refining has been the subject of two recent independent investigations, of which one has been carried out by Dr. TH. GEILENKIRCHEN in the daily practice with the Héroult furnace in the steel works of the Rich. Lindenberg Co. in Remscheid-Hasten, while the other research has been made by Prof. BERNHARD OSANN with a 1000-kg Roehling-Rodenhauser modified induction furnace in the Roehling works in Voelklingen. These two papers may be found in full in *Stahl und Eisen* of June 17 and July 15 respectively.

The fact that an effective removal of sulphur takes place in the Héroult furnace is proven by Dr. GEILENKIRCHEN by the following results of 1000 successive charges in the ordinary daily practice of the Rich. Lindenberg Co. Of these 1000 successive charges, the steel produced in

88 charges	contained up to	0.001 per cent.
5	"	0.002
14	"	0.003
29	"	0.004
50	"	0.005
82	"	0.006
100	"	0.007
168	"	0.008
99	"	0.009
108	"	0.010
67	"	0.011
64	"	0.012
35	"	0.013
29	"	0.014
20	"	0.015
11	"	0.016
14	"	0.017
6	"	0.018
1	"	0.019
2	"	0.020
2	"	0.021
2	"	0.022
2	"	0.023
1	"	0.025
1	"	0.026

It will be seen that 74.3 per cent of all charges gave a steel containing not more than 0.010 per cent S, while 95.8 per cent of all charges gave a steel containing not more than 0.015 per cent S.

These good results were not due to the use of especially pure raw materials, as is proven by the following figures which give the percentage of sulphur in the liquid steel charged into the electric furnace for refining during the same period:

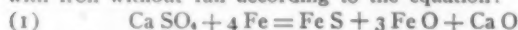
0.114	0.133	0.035	0.099	0.055	0.069
0.076	0.204	0.070	0.500	0.075	0.131
0.050	0.100	0.058	0.037	0.070	0.450
0.138	0.064	0.142	0.086	0.045	0.060
0.056	0.123	% S.			

To give the metallurgical rationale of the removal of sulphur in the Héroult furnace, Dr. Geilenkirchen first compares the latter with the basic open-hearth furnace. In the molten steel bath sulphur is chemically combined with iron and manganese. These sulphides are soluble both in the steel bath and in the slag. The amount of sulphides passing into the slag is determined by the general laws of the equilibrium between two solutions, with different solvents but the same solute. The principal rule is that the quantity of sulphides passing into the slag will be the greater, the higher the temperature, the basicity of the slag and its content of lime and manganous oxide.

These conditions can be easily fulfilled in the Héroult furnace. The temperature of the slag below the arc is exceedingly high. It is, therefore, possible to make the basicity of the slag as high as desired. It is especially possible to make the content of lime considerably higher than in any other process. Under these circumstances the removal of sulphur in the Héroult furnace in the way sketched above must proceed much further than in the basic open-hearth furnace. Nevertheless it cannot be complete from this single point of view, because according to the laws of equilibrium sulphides must always remain in the steel bath as long as the latter is in contact with a slag containing sulphides. Of course, by renewing the slag and using a new slag free from sulphur, more sulphur will be removed from the steel bath. But this method takes time and is expensive.

If the sulphur is to be removed completely, it is necessary to

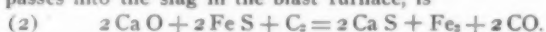
bind it quantitatively in form of a sulphide insoluble in the steel bath. The only sulphide which is to be considered is calcium sulphide. But if calcium sulphide is present in the slag, it has a great tendency to oxidize and form the sulphate CaSO_4 . According to Finkener's experiments this will react with iron without fail according to the equation:



The sulphur then passes back into the steel bath.

(It is even worse in the open-hearth furnace. Any sulphur dioxide in the flame gases, due to the sulphur content of the fuel, will tend to oxidize to sulphur trioxide and combine with the lime of the basic slag and form calcium sulphate. The latter then reacts according to the above equation, so that the final result is that a part of the sulphur in the fuel will pass into the flame gases, then into the slag and finally into the steel bath.)

With respect to the change of iron sulphide into calcium sulphide, it is known that it requires the presence of a strong reducing agent. For instance, the reaction by which sulphur passes into the slag in the blast furnace, is



The same reaction may take place in the open-hearth furnace with simultaneous reduction of the carbon content of the slag; it will take place directly at the contact surface between steel bath and slag. The same reaction will also occur in the Héroult furnace if high-carbon and high-sulphur steel is treated. However, the easiest way of operating a Héroult furnace is to feed it with molten decarbonized and overoxidized iron so that the conditions for the above reaction are not fulfilled.

In the Héroult furnace the desired change takes place within the slag itself and is a result of its reducing nature, due to the presence of calcium carbide. Calcium carbide is used for the deoxidation of the bath and forms spontaneously in the furnace under the action of the electric arc.

The strongly reducing slag first deoxidizes the steel bath in such a way that the metallic oxides pass into the slag and are reduced to metal which returns into the steel bath, while the calcium carbide is oxidized to lime and carbon monoxide. After this reaction is completed (i. e., when the slag and the bath contain no longer any metallic oxides), the reducing slag acts on the metallic sulphides and changes them to calcium sulphide exactly according to equation (2) (with the only exception that calcium carbide acts as reducing agent instead of pure carbon). In this way the sulphur content can be reduced to any desired amount, if only sufficient time is allowed for the reaction.

It is not necessary to use pure lime, free from sulphur. If the lime contains sulphur in form of calcium sulphate, iron sulphide will first be formed according to (1) and the sulphur content of the bath will be increased. But this will not affect the end result. The practically complete removal of sulphur by reaction (2) does not depend on the quantity of sulphur present. The only conditions which must be fulfilled are a sufficient amount of lime and calcium carbide and freedom of the slag from metallic oxides; as long as oxides are in the slag, they will be preferably reduced, and only after deoxidation is complete, the sulphides will be reduced.

It was emphasized above that any oxidation of calcium sulphide to sulphate would make success impossible. In the Héroult furnace this oxidation is impossible for two reasons, one being the strongly reducing nature of the slag, and the other the fact that the Héroult furnace has a neutral atmosphere, which distinguishes it sharply from the open hearth with its oxidizing atmosphere.

It is now easy to sketch the process of desulphurization in the Héroult furnace. If the treatment begins with oxidizing smelting, the oxidation is accompanied by desulphurization in the same way as in the open-hearth furnace, but to a much greater extent, because the slag in the Héroult furnace is of high fluidity and therefore a good solvent. The sulphur passes into the slag in form of sulphides of iron or manganese.

During the following deoxidation period (with which the

electric-furnace treatment will begin in general) iron and manganese sulphides will pass into the slag as long as the latter contains oxides. But this will have no effect on the final result. The removal of sulphur during the deoxidation period really begins only when the slag no longer contains metallic oxides. Then calcium sulphide is formed by reaction (2), as described before.

Practical experience confirms these views. In the beginning of the treatment the removal of sulphur is quick, as a result of increasing temperature. Then follows a period during which the sulphur content remains practically constant until the slag gets free from metallic oxides. The slag then disintegrates to a white powder. Beginning from now on, the removal of sulphur is again rapid, until the final results, given above, are reached.

In this process two points are of special importance.

First, desulphurization in the Héroult process is not a separate operation, but accompanies the deoxidation. In the Héroult process it may, therefore, be said to be impossible to retain any appreciable amount of sulphur in a thoroughly deoxidized charge; and this is true whether the sulphur content of the raw material is high or low.

Secondly, the desulphurization in the Héroult process goes on without any effect on the chemical composition of the steel bath in other respects. This is of importance for various branches of the steel industry, but especially for foundry practice, if for special castings a low content of manganese or silicon is required. Cast iron of such composition contains often too much sulphur. For such purposes a low grade of pig iron, with small amounts of manganese or silicon, may be refined in the Héroult furnace; and it does not matter what the content of sulphur is. Dr. Geilenkirchen gives the results of two experiments made in this direction. The figures given in the following analyses under "S before" and "S after" are the sulphur percentages before and after treatment in the electric furnace:

C.	Mn.	Si.	P.	S before.	S after.
3.00	0.69	2.17	0.468	0.496	0.005
3.69	0.57	0.49	0.356	0.450	traces.

In the first case the percentage of carbon was reduced in the electric furnace by addition of scrap.

In conclusion Dr. Geilenkirchen acknowledges his indebtedness to Prof. Eichhoff, who has coöperated with him in the solution of these problems.

Prof. B. OSANN, in his essay based on experiments with the Roehling-Rodenhauser furnace, also emphasizes that the removal of sulphur in the electric furnace is essentially due to the formation of calcium sulphide. His experiments were made with molten soft steel of 0.1 per cent C.

In the first period of the treatment the phosphorus is removed. This may be successfully done by means of lime and roll scale (walzsinter). Lime alone or lime and manganese ore do not give satisfactory results. The removal of phosphorus by oxidation requires evidently a substance giving off oxygen, in this case iron oxide.

Until the phosphorus is removed, it is therefore impossible to begin with carburization. Further, since removal of sulphur is possible only with a slag free from iron, desulphurization cannot start at an earlier moment. Carburization is carried out by charging retort coal in bags. Desulphurization requires a slag made from lime and fluorspar, with additions of ferro-silicon.

The refining process consists, therefore, of three steps: removal of phosphorus, carburization, and removal of sulphur. The latter two steps may start simultaneously.

Of the eight runs described by Prof. Osann the following two are reproduced in Table I because they represent normal operation (see page 407).

In the first period of the process, as shown in the tables, the phosphorus is reduced to the desired amount. The fact that after this first period the phosphorus slightly increases again is

due to the silicon addition. The old slag from the dephosphorization period had not been completely removed and the phosphoric acid in it was reduced by the silicon, so that phosphorus returned into the steel bath.

Concerning the reactions by which sulphur is removed, there was some uncertainty in the past. It was first tried to remove the sulphur by means of lime to which fluorspar was added to get a fluid slag. It was not known at that time that a slag practically free from iron was absolutely necessary. The successful removal of sulphur requires a slag of lime and fluorspar with additions of ferrosilicon.

As soon as the dephosphorization slag has been removed, ferrosilicon in large pieces (of egg size) is charged (together with the carbon for deoxidation). After a slag has been formed, the same ferrosilicon alloy, reduced to pea size, is thrown on the slag and this is repeated until the desired result is obtained.

The quantity of ferrosilicon charged in large pieces is so proportioned that the bath would contain about 0.5 per cent silicon if there were no losses. Only for steels, the silicon content of which must be low, less ferrosilicon is used. The author always used 50 per cent ferrosilicon. The ferrosilicon is first charged in large pieces because its action is intended to extend over a longer period.

The two charges 1 and 5, about which details are given above, represent normal methods of working for hard steel and soft steel respectively.

Other comparative charges, described by Prof. Osann, show that the sulphur is not removed if ferromanganese is substituted

RUN 1 (HARD STEEL)	C.	Mn.	Si.	P.	S.
After treatment with roll scale.....	0.105	0.204	0.016	0.012	0.069
Addition of 5 kg 50% ferrosilicon (egg size) and 15 kg coal. Slag made from 10 kg lime and 4 kg fluorspar. When slag was fluid, the composition of bath was.....	1.07	0.248	0.092	0.020	0.044
5 kg lime, 2 kg 50% ferrosilicon (pea size) and 2 kg fluorspar thrown on slag. Since the slag was still dark, another addition of 1 kg 50% ferrosilicon and 1 kg fluorspar was made. The color of the slag became lighter.....	1.07	0.234	0.096	0.013	0.028
Again 2 kg 50% ferrosilicon and 2 kg fluorspar added. The slag now white. Furnace tilted.....	1.05	0.263	0.25	0.016	0.008
Composition of the last slag: 28.66 SiO ₂ , 43.30 CaO, 2.59 FeO, 0.70 MnO, 0.45 S, iron 2.22.					
RUN 5 (SOFT STEEL)	C.	Mn.	Si.	P.	S.
Charged.....	0.139	0.435	0.014	0.053	0.053
After treatment with roll scale (15 kg) and lime, and removal of slag.....	0.109	0.406	0.016	0.026	0.053
Charged 6 kg 50% ferrosilicon (egg size) and slag made from 15 kg lime and 6 kg fluorspar. 10 kg of pea size ferrosilicon added.....	0.141	0.406	0.35	0.031	0.020
Some time later.....	0.127	0.406	0.34	0.031	0.016
Composition of last slag: 19.48 SiO ₂ , 63.70 CaO, 2.8 Al ₂ O ₃ , 5.44 MgO, P trace, 1.47 S, 0.77 FeO, 0.54 Fe ₂ O ₃ , 0.98 total iron, 0.09 total manganese.					

for ferrosilicon. The results are still more unsatisfactory if lime and fluorspar alone are used (or with some sand) without ferromanganese or ferrosilicon.

The analyses of the slags given for the different charges show clearly the relation between iron content of the slag and sulphur content of the bath. If the slag contains considerably more than 2 per cent of iron, the removal of the sulphur is unsatisfactory.

Prof. Osann concludes that an iron content in the slag prevents desulphurization of the steel bath, on account of the reaction $\text{FeO} + \text{CaS} = \text{FeS} + \text{CaO}$, which is a strongly exothermic reaction. He emphasizes the difference between removal of sulphur as manganese sulphide and as calcium sulphide. Sulphur is removed as manganese sulphide in the mixer. A content of ferrous oxide in the slag is not detrimental in this case (because the reaction $\text{FeO} + \text{MnS} = \text{FeS} + \text{MnO}$ evolves so little heat at ordinary temperature that it may be assumed to proceed in the opposite direction at higher temperature). A complete removal of sulphur is, however, impossible in this way. It requires the formation of calcium sulphide.

A substitute for lime has not yet been found. Alkali metals, which are preferably employed as carbonates (not as chlorides)

are effective, as experiments in Voelklingen have shown. But they are expensive and destroy the brickwork of the furnace.

The use of magnesia (which comes any way from the furnace walls into the slag) is not successful, nor the use of manganese oxide. A high content of manganese in the steel bath (up to 1 per cent) has no influence on the sulphur content below 0.05 per cent.

To reduce the iron oxides in the slag, only ferrosilicon has been found effective, besides carbon, which alone, however, is insufficient. The high oxidation heat of silicon manifests itself by inducing the reaction $2\text{FeO} + \text{Si} = 2\text{Fe} + \text{SiO}_2$ and producing a high temperature in the slag. Manganese is no efficient substitute, nor has calcium carbide been found effective in the induction furnace. The formation of calcium carbide (which is easily detected by the smell of acetylene when the white slag disintegrates or is wetted) must, therefore, be considered to be simply a secondary phenomenon. A high temperature helps the removal of the sulphur.

Prof. Osann finally remarks that possibly a gaseous compound, silicon sulphide, plays a part. This is not impossible, but has not yet been proven.*

* * *

Mr. JOH. HARDEN, writes in London *Engineering* of Aug. 14, with respect to Prof. Osann's paper, as follows:

"1. It has been found by experience that the metal bath should contain an excess of oxygen after the dephosphorization has taken place, in the first instance, in order to prevent the phosphorus wandering back into the metal again. But this is not the sole reason, as will be set forth below.

"2. It has been found that a good desulphurization and deoxidation was effected when calcium carbide was afterward found in the slag.

"3. Hence it was assumed that the carbide promoted this reaction. Ready-made carbide was, therefore, added to the bath in order to hasten the reaction, but it was found that this did not have the desired effect unless the temperature was raised to such an extent as to decompose the carbide, which may be effected in an arc-furnace (where 'good' results are said to have been obtained in this manner).

"4. A good desulphurization and deoxidation could, however, be obtained by adding carbon powder, or, still better, ferrosilicon to the bath.

"Conclusion.—Now, to my mind, the conclusion is this: To a bath of steel, containing sulphur and an excess of oxygen, we add calcium oxide. This will not, at this temperature, take up the sulphur; we also add, therefore, ferrosilicon, which is instantly attacked by the oxygen, thus raising the temperature (like aluminium and iron oxide in the thermit process). The temperature is increased chiefly on the surface under the slag blanket, and this increase of temperature in presence of the carbon at hand in the steel is sufficient to decompose the lime into free calcium and oxygen, which latter is also consumed by the highly combustive silicon. The calcium, again, having a great affinity to sulphur at this temperature, will act as a strong desulphurizer, instantly forming calcium sulphide, which may be found in the slag. A smaller part of the calcium, however, will also combine with the carbon present, forming calcium carbide.

"Consequently, the carbide is not acting per se as a desulphurizer, but its formation is only an indicator that the necessary reaction has taken place. The real desulphurizer is the free calcium, which is liberated by the combustion of the silicon, by which reaction the oxygen in the steel is consumed. Hence the necessity of an excess of oxygen in the bath in order to obtain a good desulphurization.

"A further consequence is that the presence of a large amount

*In this connection it is interesting to refer to the following note of Mr. Max Haff (our March issue, p. 96): "I have found considerable reaction on heating sulphides and silicides together. When iron containing a high content of sulphur and silicon, is heated to the high temperature existing in electric furnaces, the silicon and sulphur react. Gaseous (at that temperature) silicon sulphide is evolved. It can be easily caught and identified as such or can be absorbed by having calcium silicide in contact with the electrically heated iron. This calcium silicide, when cold, liberates sulphuretted hydrogen in contact with water."—Ed.

of carbide in the slag shows that a waste of power and heat has taken place; there should be only sufficient carbide present to indicate that the reaction has taken place. The formation of carbide is always an expensive affair, and the presence of a large amount would in this case be useless.

"If it is as stated, we also understand why an addition of ready-made carbide is of no use unless, for instance, in an arc furnace. Here, again, the carbide must be decomposed, giving free calcium for the formation of calcium sulphide, but it is obvious that such a reaction must be more costly, especially where power is expensive; then both the ready-made carbide and the ferrosilicon must be made by expenditure of power and it seems to be a waste to again spend power to decompose the former while the latter is more heat-giving in itself.

"This also explains why it is better to add ferrosilicon than carbon, although the latter can be used. If so, however, we need more power, as the reaction of ferrosilicon is in itself more heat-giving than the carbon.

"To my mind this seems to be the course of reaction in the electric furnace, but the theory may perhaps also be applied to other processes, such as the Thomas and open-hearth process."

Electrolytic Refining of Gold, Silver and Copper at the United States Mint, San Francisco, Cal.

By ROBT. L. WHITEHEAD.

(Concluded from page 359.)

The **melting room** equipment, shown in Fig. 13, consists of four melting furnaces for No. 80-100 black-lead crucibles and one reverberatory water-jacketed furnace. The hearth is 6 ft. by 3 ft. and is made of magnesia firebrick. This furnace is used for copper melting and the cupellation of base bullion. A small melting furnace and a muffle for assaying are also provided.

The whole equipment in this room is operated with California crude oil and gives entire satisfaction as to efficiency and cost. It was furnished by the Rockwell Furnace Company, New York, who were the first people to introduce fuel-oil melting into the government mints and up to the present time are the only ones who have built a successful furnace for mint work. The complete melting and annealing equipment for the Denver mint was furnished by the same firm and operated with Colorado crude oil.

The furnace design at San Francisco differs from those of the Denver equipment. Being an open-top furnace, with a circular combination chamber, it is much easier repaired and consumes much less oil, the consumption being less than 4 gal. per hour per burner. The oil is heavy and has an asphaltum base and flows very slowly, but has a greater number of heat units than Eastern oils. With seven furnaces in operation, seven hours per day, the total cost per month does not exceed \$60. This is a remarkably low expense for fuel for the metal operated on, about 500,000 oz. being melted during the month.

The system of flues and dust chambers has not been overlooked. The values which pass off during melting, pass through an individual chamber, 3 ft. x 4 ft. x 5 ft. From this chamber the gases pass through two main settling chambers, 18 ft. x 3 ft. x 5 ft., one above the other. The flues have partitions of checker work which retard the flow of the gases, causing greater condensation before they enter a flue 40 ft. long, 3 ft. wide and 3 ft. high. This latter flue opens into a settling chamber, 21 ft. x 15 ft. x 6 ft.

This chamber is built around the stack so that the outlet is on the opposite side to the entrance, thus compelling the gases to make a complete circuit of the chamber before escaping to

the air. The flues and chamber are in the attic above the melting room. There is also located here the 2000-gal. tank which supplies the two Rockwell oil pumps, only one of which is operated at a time. The main storage tank of 10,000-gal. capacity is located in the street adjoining the mint building, a steam pump being used to force the oil into the attic tank. The Sturtevant blower No. 4, located in the attic, supplies about 700 cu. ft. of air per minute to each burner at a pressure of 11 oz.

The weighing room or office of the foreman is conveniently located for handling the metals to and from the vault, which is situated in the rolling room adjoining the office.

The equipment for this room consists of one Troemner No. 5 bullion balance, weighing 6000 oz in each pan. It is sensitive to 1/100 of an oz. There is also one 3-ft. balance for weighing small bars.

A system of accounts was inaugurated in the refinery, which is a new departure, in that it enables the foreman to keep in touch with the operations in a more intelligent way.

All bullion to be refined is weighed out in melts in the melter's and refiner's office, and again weighed by the foreman on his own scales, and when any discrepancy exists, it is adjusted before receipting for it. All fine bars are first weighed by him, before being delivered, and if correct in weight, a receipt is received from the melter and refiner.

A complete refinery account is kept by the assistant foreman, computations of receipts and deliveries being carefully made and checked with the melter and refiner's office, before entering into the refinery books. As the two accounts are compared from time to time there is no chance of error.

The system has this further advantage that the foreman can tell from time to time just how he stands as to the accumulation of metal in the process, and can keep his odds and ends worked up close. The government refineries do not work as close as outside plants, possibly because there are no interest charges on the values tied up. But this is really no excuse, for the metal is never as safe in the refinery as in the melter and refiner's



FIG. 13.—MELTING ROOM.

vault. It is very hard to start anything new in the government service, as it always meets with opposition, and very frequently from sources one least expects. Of course, we always look for it from the average workman.

The rolling room, which is the last of the rooms at present equipped, has an acid-proof stone floor. The slabs are 30 in. x 30 in. x 1½ in. in dimensions. In the middle of this room is a 10 x 8 water-cooled rolling mill driven by a 15-hp Westinghouse 230-volt, direct-current motor.

The mill is used for rolling cathode sheets of fine gold; the ingots to be rolled are $\frac{1}{2}$ in. thick, $3\frac{3}{4}$ in. wide and 14 in. long and when finished are about 60 ft. long, $\frac{1}{8}$ in. wide and 1/100 in. in thickness. By means of a special guide, designed at the Denver mint, the ingots are rolled out to this length without cutting. The guide contains 12 steel rollers, six on a side, set vertically. The object of the rolls in the guide is to prevent the buckling of the long strips in passing through the rolls, which trouble increases as the strips get thinner. By having the strip in one

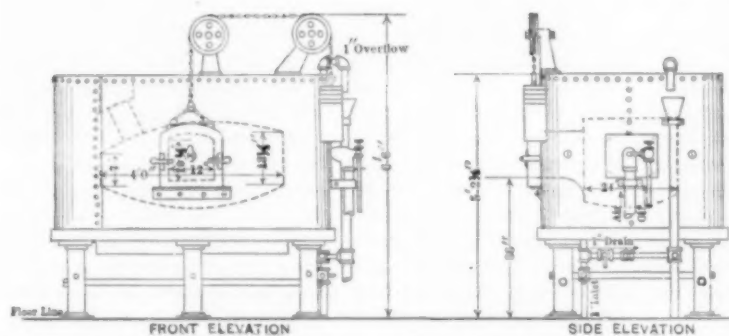
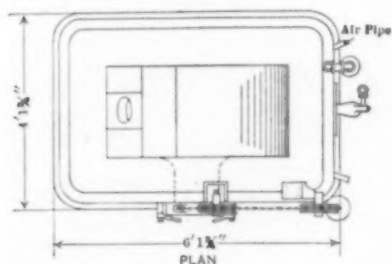


FIG. 14.—WATER-JACKETED COPPER FURNACE.

continuous piece, very little scrap is made in cutting cathodes, which are about 10 in. long. About 300 cathodes are used every 24 hours. The cutting machine is operated by a 3/4-hp motor, with an adjustable bed for any length of cathode, can easily be operated by one man. The rolling, annealing and cutting of cathodes is done in this room in about two hours' time.

A 150-ton hydraulic press operated by a 5-hp motor is located in the extreme end of the room. At present there is little use for it except to press such material as cement copper, slimes or other finely divided material before melting.

In connection with the layout of the rooms which constitute the refinery, are dressing and toilet rooms. The dressing rooms have steel sanitary lockers. The toilet and shower baths are finished with the same kind of stone as the floors, the whole room having a decided sanitary appearance.

A comparison of the methods used by the mints will be interesting to the readers of this paper, in ascertaining to what extent the methods are valuable from a commercial standpoint.

The method of silver refining in use at San Francisco is well known to the commercial world, being the Thum process with certain modifications, for instance, with respect to circulation of the electrolyte. This entails a larger volume of solution, but enables one to purify it to a better advantage, especially when working anodes with from 5 to 10 per cent of base. I will not go into detail about this process, but will refer to that used by the other mints, which is generally known as the vertical or Tuttle process.

With this process installed in any establishment it is necessary to have a rolling mill for making the silver cathodes. The anodes and cathodes are about 3 in. apart. The anodes are bagged individually. As the composition of the anodes contains 1/3 in a thousand in gold, the gold remains intact and there is very little weight on the bag. In outside plants it would

be different. As few plants have as much as 50 parts per thousand in gold, it would fall off as a mud and would work through the bag. Besides the propeller system of circulation causes too much agitation in the tank.

The deposit is coherent only in a way. The cathodes have to be taken out each day and scraped to knock off the trees which form, to prevent short-circuiting. Further, over 10 per cent of the deposit falls to the bottom of the tank.

The great drawback to the process from a commercial standpoint is the low current density required to obtain this coherent deposit (from 7 to 8 amp per square foot of cathode surface on the start and toward the end from 4 to 5), thus tying up the silver and gold in the tanks about eight days.

The only feature which would be attractive is the low voltage per tank, as compared to the Thum process, namely, 1 volt as compared to $3\frac{1}{2}$.

The coherent deposit is obtained by the use of gelatine, the idea having originated with Anson G. Betts in electrolytic lead deposition, where he uses glue.

The silver deposit that falls to the bottom of the tank in one of the mintse is melted and run through the Thum process, while in another mint it is used together with the daily scrap-

ings from the cathodes to convert it into silver nitrate in replenishing the electrolyte in silver. Just how much is used for this purpose is not known. The anode residue of gold, which is solid and resembles chocolate in color, generally has a core of silver running through it, and has to be boiled first in nitric and finished in sulphuric acid. This is done so as to get an anode sufficiently low in silver for the Wohlwill process, as all gold from the silver tanks has a second electrolytic separation.

The purification of the electrolyte in this process is a very important adjunct. As the anodes generally contain 10 per cent lead, bismuth, copper and zinc, a large volume has to be removed each day. The silver is precipitated with salt. The filtrate con-

taining the copper is run into the sewer. It has been considered necessary at one of the mints to heat the electrolyte and carry 5 per cent of free nitric acid in solution. This appears absurd to me, and accounts for the large amount of acid used at this institution as it decomposes and fills the atmosphere of the room with nitric acid fumes.

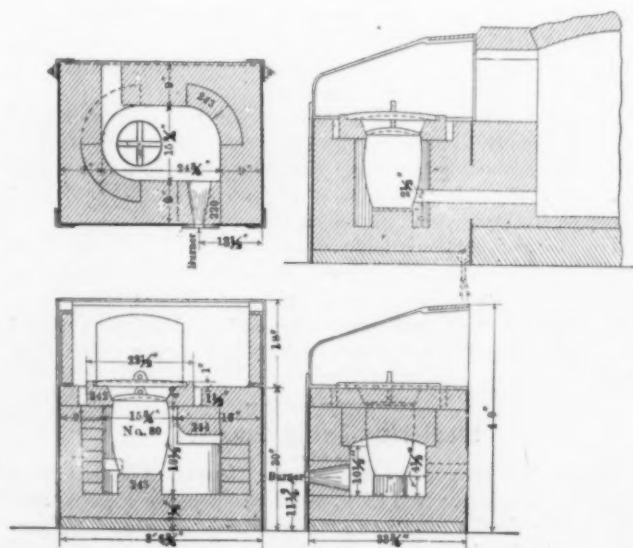


FIG. 15.—CRUCIBLE MELTING FURNACE.

The reason given for it is that the anodes work out more uniformly and will stand a higher percentage of gold. It is claimed the anodes contain 390 parts gold per 1000. Whether the

conditions warrant the large consumption of acid and the foul atmosphere resulting from it is a question.

In a former article on the Denver mint equipment I suggested certain features of the Wohlwill gold process which might interest the commercial plants. I am not surprised that they have not tried it after going through the government plants, where they see so much gold tied up in the process, naturally concluding that it is necessary. The electrode bars are covered with strips of fine gold, the hangers are the same, also a large stock of gold chloride is always on hand, as well as a goodly stock of anodes and cathodes.

In an industrial plant this can be made vastly different, viz., the electrodes can be covered with strips of fine silver, also the hangers can be made of the same material. More attention will be required as regards contacts. I would not advocate immersing the hangers into the bath, as that would give a much poorer contact and only save very little scrap.

In regard to cathodes, I would use rolled fine silver and strip them, only presenting one side for deposit, one line of anodes and two lines of cathodes. This can easily be done, as I have made proof gold by stripping the deposit from a strip of gold 998.5 in fineness, this, of course, with the deposit only on one side. It would be necessary, though, to have several tanks for this purpose, using a current density of 150 amp per square foot of cathode surface. Eighty-five per cent of the gold could be refined in 24 hours, the remaining 15 per cent in 48 hours.

The gold constantly tied up would be the amount in the electrolyte, which would vary with the production of the plant. As all fine bars from industrial works that reach the mints with few exceptions contain platinum in small quantities, this metal would be saved and to some extent offset the interest charges. When one considers that the government refineries are saving yearly about \$50,000 worth of platinum with very little expense and for which nothing is paid, it is about time some experimenting on the part of the industrial plants was under way to test the matter fully from a commercial point of view.

The use of silver cathodes would in all probability lower the fineness of the deposit by a half point. However, there is no advantage for an industrial plant in depositing gold as fine as the mint gold, 999.5. They would get no more for it and only save a little silver.

In most outside plants it is necessary to nitre the melted gold to remove lead, bismuth and tellurium, and sometimes selenium. Otherwise it would be brittle and be subjected to a toughening charge at the mints. This process is costly and entails a loss. By the electrolytic process these metals are all removed and the cathodes, as soon as melted, are poured into bars, thereby reducing the melting loss to a minimum.

It would only be necessary for the plants to boil their gold mud sufficiently to make anodes from 850 to 900 fine. At San Francisco no boiling was required; only thorough washing was necessary. As this was done in a centrifugal, the gold mud could be washed free of nitrate of silver.

Having worked the sulphuric acid process of refining silver and gold for a number of years, and electrolytic gold refining for the past four years in the government mints, I believe that outside plants, with their progressive and hustling spirit, would soon make the Wohlwill process of gold refining a commercial success.

Steel Hardening Furnace.

At the last general meeting of the German Association of Electrical Engineers Mr. C. R. STRAUBE presented a paper giving further details on the electric hardening and annealing furnace with fused electrolyte, which was described before in papers of L. M. Cohn, noticed in our Vol. 4, page 367, and Vol. 5, page 428. A furnace of this type (which is controlled by the Allg. Elek. Ges., of Berlin, and the General Electric Company, of this country) was shown in the exhibit of Mr. C. J. Russell at the last Philadelphia meeting of the American

Electrochemical Society, as noticed in our Vol. 5, page 233.

Mr. Straube's paper, which may be found in full in *Electro-technische Zeitschrift* of Aug. 6, begins with a tribute to the research work of Mr. W. Taylor on high-speed steels. In their manufacture the method of hardening is of prime importance. The steel articles to be hardened must be heated to an exactly defined temperature which varies with the nature of the steel. For carbon steels the required temperature is between 700 and 900° C., for ternary or quaternary steels it is higher, for instance, above 1100° C. with Taylor-White steel containing 18 per cent W, 5.5 Cr, 1.0 C, 0.15 Mn. Modern high-speed tool steels, i. e., chromium-tungsten steels, must be hardened at 1300 to 1350° C. This temperature is near the melting point.

Evidently it must be possible to produce temperatures between 700 and 1350° C. in a hardening furnace. To be successful it is further necessary that the heating takes place quickly, and that the temperature can be adjusted, so that the difference from the desired temperature is certainly less than 30°. Further, the heating must take place in the absence of oxygen and of fuel gases. Finally one of the most important requirements is that the temperature be uniform within the furnace.

In a muffle furnace the temperature in the center is lower than near the walls. This fact caused a peculiar error in a factory which formerly used muffle furnaces and then introduced the electric furnace described below. In the muffle furnace the temperature for hardening different kinds of steels had been carefully determined in the central zone of the furnace. When the same temperature was then produced in the electric furnace it was found to be not sufficient for hardening. The reason was that the former temperature determinations in the muffle furnace had been made in the center, while the steel parts to be hardened (teeth, edges, etc.) were near the walls. Since near the walls of the furnace the temperature was higher than that measured in the center of the furnace, the measured temperature did not give the correct hardening temperature. For the electric furnace with its absolutely uniform temperature, a higher temperature had, therefore, to be employed than existed in the center of the muffle furnace.

The electric furnace for hardening steel consists essentially of a firebrick crucible, two opposite sides of which contain iron electrodes very low in carbon; the melting point of such iron is 1500 or 1600° C.; that is, higher than that of any steel. The crucible is surrounded by a dense layer of asbestos, which is again embedded in a layer of refractory material which is a non-conductor of heat, the whole being held together in a steel box. After 10 hours' operation of the furnace at 1350° C. it is possible to touch the iron walls with the hands without any danger. Heat conduction is, therefore, reduced to a minimum.

The connections to the low-carbon steel electrodes are also made of soft steel, and these are connected to the secondary copper bars of the regulating transformer. This transformer reduces the primary voltage (110 to 550 volts, single-phase) to 5 to 70 volts.

Fig. 1 shows the hardening equipment of a modern high-speed tool factory. The electric furnace is in the center. At the right the regulating transformer and controller are seen, while the quenching tank is at the left. The proximity of the latter to the furnace is perhaps the most interesting feature of the picture. Various pipes lead to the cooling tank to supply steam or cold water to pipes within the tank, so as to regulate the temperature in the tank at will.

The crucible of the furnace is filled with a molten electrolyte and the article to be hardened is simply placed within the fused salt bath. According to the steel to be treated, the nature of the fused salt is chosen. The intention is to use a salt with a melting point very near to, but below, the eutectic temperature of the steel. Potassium chloride, with a melting point of 775° C. is used, for instance, with carbon steels. Barium chloride, with a melting point of 950° C., is used for high-speed tool steels, and mixtures of bath salts are used for mean temperatures. For temperatures between 200 and 400° C. potassium and

sodium nitrate may be used; for temperatures between 1300 and 1600° C. fluorspar and magnesium fluoride.

To fuse the solid salt, which is fed into the furnace, an auxiliary electrode is employed which is connected by a cable with one of the two electrodes of the furnace. A piece of arc-lamp carbon is placed between this auxiliary electrode and the other electrode of the furnace. The salt around the arc-lamp carbon is first fused and by moving the auxiliary electrode gradually further away it is easy to bring the whole bath into a state of fusion. During fusion of the salt a higher e.m.f. is required on account of the greater resistance.



FIG. 1.—ELECTRIC HARDENING FURNACE IN TOOL STEEL WORKS.

Regulation of the temperature is accomplished by the regulating transformer, by means of which certain numbers of primary windings can be switched on or off. By further varying the nature of the salt it is easy to adjust the temperature exactly. Electrolytic effects of the alternating current are hardly noticeable at a frequency of 25, while they are practically absent with a frequency of 50 periods.

The latest improvement of this furnace is the possibility to connect it to a three-phase system. For this purpose the three-phase currents are changed within the regulating transformer by means of the well-known Scott method into two-phase currents, and the latter are supplied to the bath through four electrodes. The two pairs of two electrodes are placed alongside the four sides of the furnace so that the furnace represents

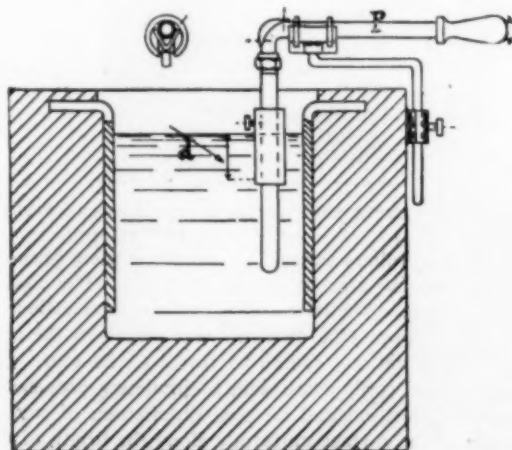


FIG. 2.—METHOD OF TEMPERATURE MEASUREMENT.

really a combination of two single-phase furnaces. The temperature within the furnace can be made practically constant throughout the bath. While the salt is brought to fusion, the three-phase system becomes unbalanced, since in the beginning

one phase only of the secondary two-phase system is loaded. Fusion is obtained in the same way as with the single-phase furnace described above, but the auxiliary electrode is not carried over to the other electrode of the same phase, but to one electrode of the other phase, and in this way it is accomplished that the system remains unbalanced for 5 or 10 minutes only.

The heating of the steel articles within the fused bath takes place, of course, in the absence of oxygen. Moreover, when the steel articles are taken out of the bath, there remains on the surface a thin adherent layer of salt which prevents any oxidation by the air. Only when the articles are placed within the quenching tank, this layer of salt cracks off.

In the old lead-bath or salt-bath furnace heated from the outside, the temperature of the bath decreased whenever a steel article was introduced, and it took some time to bring the temperature again to the desired degree. On the other hand, in the electric furnace when a steel article is introduced the level of the bath rises and the cross-section is thereby increased so that more current flows through the bath and the decrease of temperature due to the introduction of the steel article is thereby automatically compensated by the increase of Joulean heat.

It is easy in the electric furnace to adjust the required temperature within 10° C., and the temperature is practically constant in all parts of the crucible. Fig. 2 shows the measurement of the temperature by means of the pyrometer P.

The iron tube, bent at a right angle, contains at the lower end of its vertical arm the joint of a platinum, platinum-rhodium element, within various protective covers. The two terminals at the outside end of the horizontal arm are connected by two wires to a galvanometer, on which temperatures up to 1600° C. can be read directly.

A special protecting muffle is placed on those parts of the pyrometer tube along which the changes of level of the bath take place. The pyrometer tube itself is thus protected against any deterioration from change of level. *d* in Fig. 2 represents the change of level.

A layer of about 10 mm thickness below the surface of the bath is by 10 to 20° colder than the balance of the bath. With this exception the temperature is practically uniform throughout the bath. No greater differences of temperature than 3° C. have been found.

Cost of Electrolytic Hypochlorite.

As noticed before electrolytic hypochlorite is used as disinfectant in the Metropolitan Borough of Poplar in England. From last year's report of the medical officer, Dr. F. W. Alexander, noticed in our English contemporaries, we took the following figures on cost of operation:

Condition of Plant.—The wear and tear has been practically nothing to speak about. The plant after two years is still in good working order, turning out 185 gal. of solution in eight hours at an average strength of 4.5 to 5.0 gr. of chlorine per litre. It has not been necessary to renew any of the zinc electrodes, which, from their present condition, no doubt, can be used for a much further period. To prevent the salt from acting upon the iron, the interior of the large supply tank has been coated over with "rosbonite," a preparation which answers admirably. The saturators have been treated in a like manner. There has been introduced a very simple arrangement to insure the mixing of the preservative (hydroxide of magnesia) and a large amount of labor is also saved.

Cost of Plant, Etc.—Total cost up to date, January 31, 1908, of depot, plant, fittings, alterations, painting, testing, apparatus, carboys, syphons, etc., \$2,955.66. Initial outlay, 1906, was \$2,841.42, which shows that \$114.24 has been expended during the years 1906 and 1907 for carboys, sundry additional apparatus, repairs to depot, new electric light, paint, "rosbonite" and minor details.

Output.—The electrolytic disinfecting fluid manufactured from February, 1906, to January 31, 1908, a period of two years,

amounted to 32,586 gal., of an average strength of 4.5 gr. to 5.0 gr. of chlorine per litre (4.5 to 5.0 per 1,000). There was supplied, at a charge of 2 cents per gallon, to the works department (for watering roads, flushing gullies, sewer manholes and market places), 13,656 gal.; gratis to Guardians' institutions, October, 1906, to January 31, 1908, 13,800 gal.; gratis to managers of sick asylums, 642 gal.; and distributed to the public from the Council's four depots (including fluid supplied to Poplar and Bow Baths), 16,908 gal.; total, 32,586 gal.

Cost of Manufacturing.—The cost of electricity and materials in the manufacture of the 32,586 gal. of disinfecting fluid from February, 1906, to January 31, 1908 (a period of two years), was: Electricity (4,888 kw-hours at 3 cents per kw-hour), \$148.78; salt (at \$5.84, \$6.32 and \$7.79 per ton), \$44.80; chloride of magnesium (at \$18.87 and \$21.91 per ton), \$70.49; caustic soda (\$1.74 per 48 lb.), \$34.74; water, \$7.55; total, \$306. Corks, paraffin wax, labels and bottles cost, from February, 1906, to December, 1906, \$623.15; and from January 31, 1907, to January 31, 1908, \$111.44, while for the same two periods the testing reagents accounted for \$11.69 and \$13.64 respectively.

If carbolic acid disinfectants had been issued in place of electrolytic fluid for the period of two years from February, 1906, to January 31, 1908, based upon the expenditure of 1905, the amount expended would have been almost \$10,000, while the actual cost of electrolytic fluid for this period was less than \$5,000. This is a saving of about \$5,000 in two years, no consideration being taken of the 13,656 gal. supplied to the works department for watering roads, etc. Each cart for conveying away sludge from the street gullies is furnished with a 4-gal. jar of fluid, and instead of dusting around the gullies carbolic powder, there is sprinkled electrolytic fluid by means of a small ordinary watering can.

Since the initial outlay of building depot, plant and appliances was \$2,841.42, and repairs to depot, etc., during the years 1906-7 have amounted to \$114.24, making a total of \$2,955.66, the initial expenditure has not only been saved, but also a sum of about \$2,000. Also the rent of the manufacturing depot, \$150 per annum, is no loss to the borough, as the amount is paid into the electricity department's account.

The Direct Production of Copper Tubes, Sheets and Wire.*

By SHERARD O. COWPER-COLES.

The numerous processes involved in the production of suitable pure copper and its subsequent conversion into copper sheets, tubes and wire, by a series of operations, such as rolling, drawing and annealing, would occupy too much time to be referred to even briefly. The author has limited the paper to the direct production of copper tubes, sheets and wire by electrolysis from impure copper.

The methods described are all based on the work of Davy and Faraday's well-known fundamental law on electrolysis. If a pure copper electrode is connected to the positive pole of an electric circuit and placed in the solution of a pure copper salt, a weight of copper will be deposited upon the cathode connected to the negative pole, equal to the amount dissolved from the anode.

If the anode is of impure metal many difficulties are introduced, and if the current density is increased sufficiently to enable the metal to be deposited at such a rate as will give commercial results, other serious difficulties arise. Electrometallurgists have been working for 30 years or more devising methods to overcome the difficulties experienced in applying Faraday's law to the commercial production of copper tubes, sheet and wire from comparatively impure copper, so as to get the physical properties of wrought copper, while depositing at a sufficiently rapid rate.

The refining of copper by electrolysis has now assumed vast

proportions, and the annual output of electrolytic copper in the year 1907 has been estimated at 400,000 tons, equal to 56 per cent of the world's production, and the capital invested in the industry at about \$75,000,000. The whole of the copper thus produced is in the form of rough slabs or cathode plates which have to be smelted and worked to the desired forms.

Electrometallurgists have been striving for many years to devise a process which does away with the smelting of copper after it has been electrolytically refined, and to electrodeposit copper at the end of the refining operation in such a form that it can be placed direct on the market as finished sheets, tubes and wire.

Wilde's Process.—It was observed shortly after Elkington practically applied Faraday's law to the refining of copper in the year 1865, that the current density (hence simultaneously the

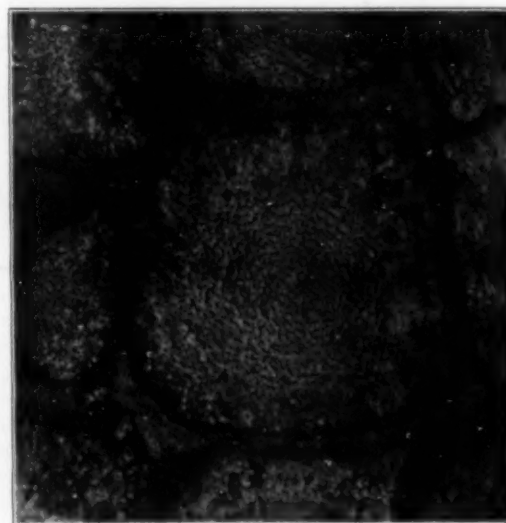


FIG. 1.—CATHODE SURFACE, LEAD COATED WITH COPPER, SHOWING EFFECT OF IMPINGEMENTS OF JETS OF ELECTROLYTE.

rate at which the copper is deposited) could be considerably increased by circulating the electrolyte or moving the electrodes. It was soon found that circulating the electrolyte alone was unsatisfactory, and that the best results could be obtained with a vertical mandrel revolved in the electrolyte. Wilde was one of the first to use a cylindrical cathode, his object being to deposit

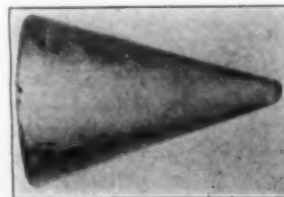


FIG. 2.—COPPER CONE TO DETERMINE CRITICAL SPEED.

copper on iron rollers suitable for textile printing purposes, for which he took out a patent in the year 1875. The anodes consisted of copper cylindrical tubes, and the iron cylinder to be coated with copper (the cathode) was placed in the center of the cylindrical vat and caused to rotate on its axis. Such an arrangement, in conjunction with a circulating propeller placed in the electrolyte, ensured an even distribution of copper over the whole of the surface uniformly along the length of the roller by means of the motion imparted to the solution, and the equal density thus maintained. The current density was low, considerably under 20 amp per square foot.

Elmore's Process.—The next development of importance was the Elmore process, which consists of using horizontal mandrels on which copper sheets or tubes are deposited, while agate

*A paper presented at the Bristol meeting of the (British) Institution of Mechanical Engineers, July 26, 1908.

burnishers travel continuously over the copper so as to consolidate it, and at the same time prevent the growth of copper trees or nodules. Even with the use of a burnisher, the current density could not be increased beyond 30 amp per square foot, and the mechanical difficulties introduced by the burnisher are considerable. Large works were erected to operate this process near Leeds and in Continental Europe, and are principally engaged in the production of large tubes and cylinders for special purposes.

Dumoulin's Process.—Dumoulin introduced, at a latter date, a process for burnishing copper during deposition with sheepskin as a substitute for agate, and claimed that the process had also

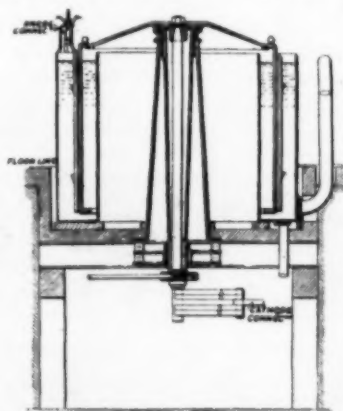
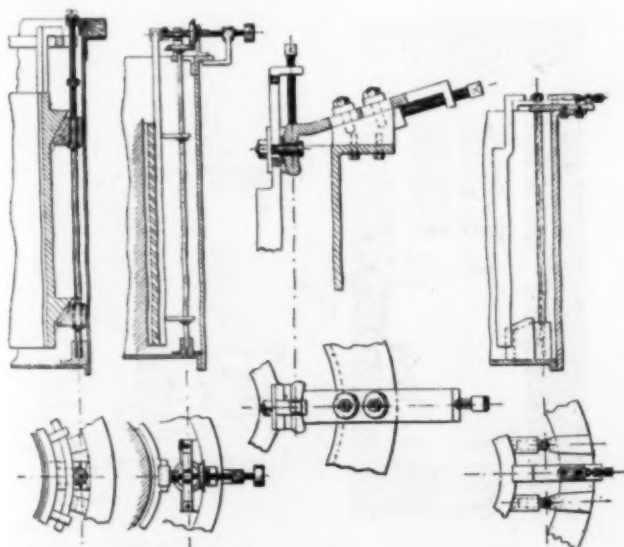


FIG. 3.—VAT USED FOR CENTRIFUGAL PROCESS.

the advantage of insulating any projections that might be formed on the deposited metal, the sheepskin impregnator coating all projecting parts within a thin film of animal fat, thus preventing further deposition until the surrounding depressions are raised to the common level. It was also claimed for this purpose that a current density of from 30 amp to 40 amp per

FIG. 4.
WEDGE.FIG. 5.—ECCEN-
TRIC AND SCREW.FIG. 6.—UNI-
VERSAL.FIG. 7.—SLIDE
AND WEDGE.

square foot of cathode surface could be employed at a voltage of about 1.6 per vat. This process was tried on a large scale in England, but was soon abandoned.

Other Processes.—Attempts have been made at various times to further increase the rate of deposit by Swan, Elmore, Thofehrn, Graham, Poore and others, by impinging jets of the electrolyte against the cathode surface. The quality of the copper is liable to vary in density if impinging jets alone are employed; it is, therefore, necessary to move the cathode, otherwise the

copper is deposited in the form of annular rings of varying density and smoothness, as shown in Fig. 1, which is a photomicrograph of a lead plate coated with copper by an impingement process at a current density of 160 amp per square foot (9.29 cm^2), temperature 50° C. ; the electrolyte being forced

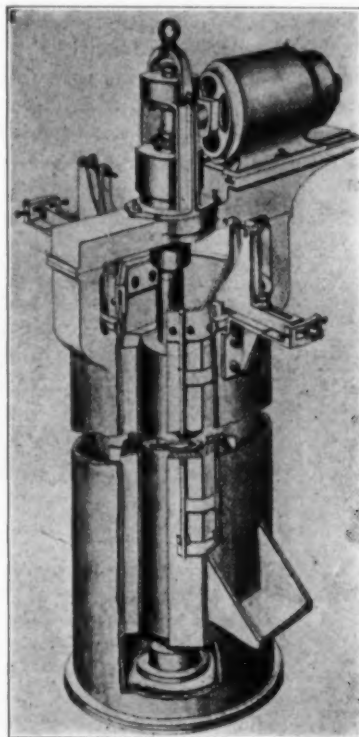


FIG. 8.—APPARATUS FOR DEPOSITING COPPER ON IRON ROLLS.

at a pressure of a few pounds through a lead box perforated with $\frac{1}{8}$ -in. (0.32 cm) holes at a distance of 1 in. (2.5 cm) apart from center to center.

The author when carrying out some experiments on the production of copper tubes and sheets by electro-deposition on

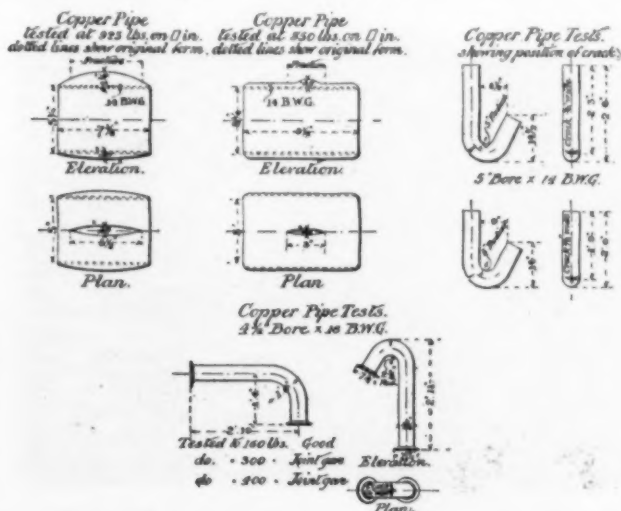


FIG. 9.—MECHANICAL TESTS ON COPPER PIPE MADE BY THE CENTRIFUGAL PROCESS.

rotating cathodes, observed that when the speed was greatly increased, entirely new results were obtained, and that a current density of 200 amp or more per square foot could be employed, the copper remaining smooth and having a tensile strength equal to the best rolled or drawn copper, and in some cases a tensile strength some 50 per cent higher than that obtained by the

ordinary process of casting and rolling, the tensile strength increasing with the rate of rotation of the mandrel. The result of revolving a mandrel at a comparatively high speed is that every molecule, as it is deposited, is burnished or rubbed down so as to produce a tough, fibrous copper, the usual order of things being reversed, the present practice being to put the mechanical work into a mass of copper by rolling or drawing instead of treating each molecule separately.

Centrifugal Process.—This observation led to further experiments, which resulted in evolving the process now known as the centrifugal copper process for the manufacture of sheets, tubes and wire, which will now be described in detail, together with the result obtained.

After a long series of experiments had been made to deter-

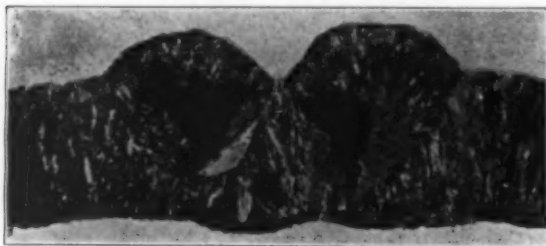


FIG. 10.—RADIAL CRYSTALLINE STRUCTURE OF COPPER NODULES.

mine the best composition for the electrolyte and the most economical current density to employ, the critical speed was accurately determined by means of revolving cathodes in the form of cones, Fig. 2. By observing the point at which the copper remains smooth, and by measuring the circumference of the cone at that point and multiplying it by the number of rotations per minute, the critical speed is readily determined; 200 amp per square foot is found to be the most economical current density, although a current density up to 500 amp per square foot can be employed by increasing the rate of rotation, but the increased cost due to increased voltage renders such a current impracticable for ordinary commercial work.

One of the chief difficulties inherent in any electrolytic or wet process for the production of copper tubes and sheets is having any working parts, such as bearings, in an acid copper sulphate

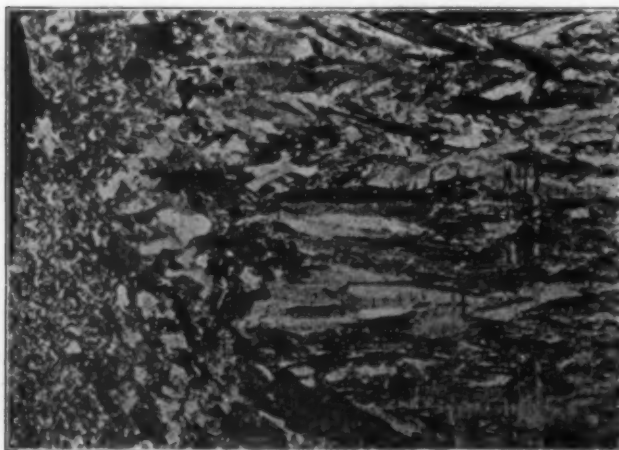


FIG. 11.—CRYSTALLINE STRUCTURE OF DEPOSITED COPPER.

solution, and this was one of the first troubles encountered when working the centrifugal process on a commercial scale. This difficulty was eventually overcome by constructing vats in the form of an annular ring, as shown in Fig. 3. It will be observed that by such an arrangement all working parts are outside the vat and do not come into contact with the electrolyte, so that the bearings can be lubricated in the ordinary way; only the actual face of the mandrel on which the copper is to be deposited

is immersed in the electrolyte. The cathode consists of a steel or cast-iron cylinder closed at one end, to which is attached on the inside a steel rod projecting below the edge of the mandrel to guide it into position; the cylinder can be 5 ft. or 6 ft. in diameter, or even larger, so as to produce a copper sheet of, say, 20 ft. long by 4 ft. or 5 ft. broad. Anodes composed of crude copper are placed around the mandrel with intervening spaces and are fed forward by suitable mechanical means, Figs. 4 to 7, as the copper dissolves away so as to keep the voltage constant.

One great advantage of the centrifugal process is that a very low voltage is required even when employing a very high current density; for instance, only 0.8 of a volt is required at the terminals of the vat when working at a current density of 200 amp per square foot of cathode surface. The effect of revolving the cathode is five-fold: firstly, it keeps the electrolyte agitated, so that there is always a fresh supply of copper ions in proximity to the cathode; secondly, each molecule of copper as it is deposited on the cathode is burnished or rubbed down by

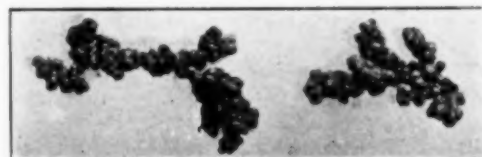


FIG. 12.—COPPER TREES. EFFECT OF FREE ACID ON NODULE FORMATION.

(The three samples in the upper diagram and the two in the lower one relate respectively to no free acid, 2 oz. H_2SO_4 to gal.; 6 oz. H_2SO_4 to gal.; 8 oz., etc.; 10 oz., etc.)



FIG. 13.—ATOMISER.

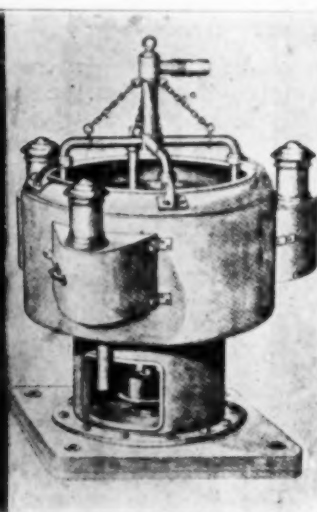


FIG. 14.—FILTER.

means of the skin friction between the revolving cathode and the electrolyte; thirdly, the rotation prevents any foreign matter that may be in suspension in the electrolyte settling on the cathode and becoming entangled by further copper being deposited around or over it; fourthly, it brushes away any air bubbles on the cathode, which are the cause of nodules forming, and, fifthly, the rotation of the cathode ensures the thickness of copper being uniform even when a mandrel of, say, 8 ft. in length is employed.

The method of making tubes by the centrifugal process is as follows: A mandrel somewhat smaller than the finished internal

diameter of the tube is prepared by coating it with an adhesive coating of copper by first depositing copper upon the surface from an alkaline solution and then thickening it up in an acid solution, the surface being highly burnished and treated chemically to ensure the easy removal of the deposited tube.

The mandrel thus prepared is then placed in a vat, as shown in Fig. 3 or Fig. 8, according to the diameter of the tube and its length. When the desired thickness has been obtained the mandrel is removed and placed in a horizontal or vertical lathe, and a round-faced roller run over the surface so as slightly to expand the deposited copper, which can then be readily drawn off.

Copper sheets are prepared in a similar manner, the only difference being that the mandrels are of much larger diameter

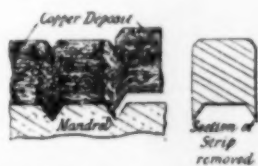


FIG. 15.—FORMING WEAK LINE OF CLEAVAGE DUE TO CRYSTALLINE STRUCTURE.



FIG. 16.—EFFECT OF SHARP AND ROUNDED CORNERS ON CRYSTALLINE STRUCTURE OF METAL CASTINGS.

and a narrow insulating strip is fitted down one side so that the sheet can be easily removed by inserting a tool under one of the edges of the deposited copper. It is no more costly by the centrifugal process to make thin sheets than thick ones; copper foil can be made in five minutes direct from crude copper.

Copper tubes produced by this process without any drawing have given a maximum stress of 17 tons, and tubes after drawing have withstood a pressure of 3000 lb. per square inch without showing any signs of distress, as shown by the following test made by Mr. David Kirkaldy:

Diameter outside, inches.	Thickness of metal (mean), inch.	Length, inches.	Weight per foot, lb.	Subjected to a pressure, lb. per sq. in.
1.123	0.063	4.94	0.814	3,000

Sheets made without any rolling have given a maximum stress of 28 to 30 tons and more per square inch according to the peripheral speed at which the mandrels were revolved. The following are some tests made by Mr. W. Harry Stanger:

Dimensions, in.	Area, sq. in.	Reduction of area at fracture, per cent.	Extension on 8 in., per cent.	Elastic limit (yield point), on original lbs., per sq. in.	Maximum stress, on original area, tons (2,000 lb.), per sq. in.	Remarks.
1.109X 0.006	0.0066	31.8	21.1	20.4	25.5	Fair break in center.
1.135X 0.007	0.0079	17.7	20.4	28.4	28.4	Fair break in center.
1.114X 0.005	0.0055	...	6.3	22.4	34.6	Specimen broke outside datum points on slightly larger area.
1.124X 0.008	0.0089	...	14.4	22.6	27.7	Specimen broke outside datum points on slightly larger area.
1.114X 0.01	0.0111	18.9	12.0	...	27.3	Fair break.
1.121X 0.011	0.0123	24.4	20.0	18.2	27.3	Fair break.

Bending test. Strip bent three times upon itself. No cracks.

Fig. 9 shows the result of some mechanical tests on copper pipes made by the centrifugal process and subjected to hydraulic pressure, giving results far above those required by the (British) Board of Trade.

The formation of copper trees and nodules was another difficulty which had to be overcome, but which had to be reduced to a minimum in the centrifugal process, for the reason that impurities held in suspension in the electrolyte have no oppor-

tunity of settling on the cathode, and all gas bubbles are swept from the surface on which the copper is being deposited.

Fig. 10 is a section of two nodules which illustrate the way in which they crystallize radially from a microscopic nucleus differing in their structure from the copper sheet which crystallizes at right angles to the surface of the cathode, as is clearly shown in Figs. 10 and 11, thus forming a weak line of cleavage, enabling the nodules to be easily separated from the copper sheet. For this reason it is impossible to produce a good sheet by any after-process of rolling.

The form of the nodules or trees is largely dependent on the amount of free acid in the electrolyte; if the percentage is high, the form is rounded; if the percentage is low, then the growth is more fern- or tree-like (Fig. 12).

The percentage of free acid employed in the centrifugal process is high, amounting to 12 or 13 per cent. The electrolyte, the usual composition of which is 12.5 per cent of copper-sulphate and 13 per cent of sulphuric acid at a temperature of 40° C., is kept in the cupric state and the impurities in suspension separated by means of a centrifugal filter provided with arc lights and an atomizer for breaking the solution up into a fine spray, as shown in Figs. 13 and 14, respectively. It has been found that subjecting the solution to a strong light the impurities are more easily precipitated and no solution is kept in the cupric state.

The production of copper wire by electrolytic means is a more difficult problem than the production of copper tubes and sheets. Various processes have been suggested and tried from time to time, such as the electrodeposition of copper on thin wire until it has obtained a considerable thickness,

and then drawing the thickened wire down to a comparatively fine wire. Swan and Saunders have both experimented with such processes, but so far they have not been worked commercially.

Elmore's process consists of producing copper tubes by his burnishing process, cutting them into long spirals and then drawing them into wire.

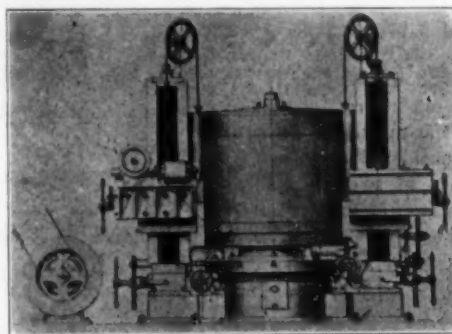


FIG. 17.—GENERAL ARRANGEMENT.

Other experimenters have tried placing an insulated spiral strip on a cylindrical mandrel so as to produce long copper spirals, but such an arrangement only allows of a very low current density, being employed, on account of the nodules which form on the edges of the strip, even at very low current densities, rendering the strip unsuitable for drawing down into wire.

Copper wire is made by the centrifugal process in the follow-

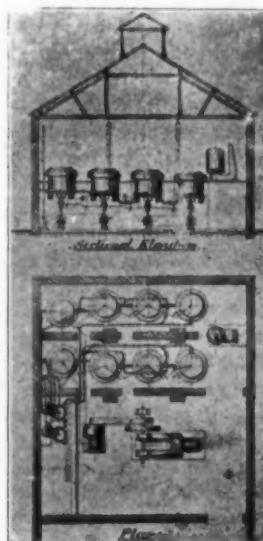


FIG. 18.—LATHE FOR UNWINDING COPPER STRIP.

ing manner: A mandrel similar to that used for making copper sheets is employed, around which a spiral scratch is made, the pitch being determined by the size of wire required.

The effect of the spiral scratch (which need only be very light, but must be angular) is to cause the crystalline structure of the copper to form a cleavage plane, as shown in Fig. 15. It will be observed that the copper divides exactly at the apex of the scratch; that is, the copper deposited in the scratch is equally divided and forms a small V-shaped fin on two sides of the copper strip, Fig. 20. If the scratch is not angular, but rounded at the base, the copper will not divide, as the crystals are radial, as shown in Fig. 16.

After the desired thickness has been obtained, approximating the pitch of the spiral scratch, the mandrel is removed from the depositing cell and placed in a vertical position on a lathe, Fig. 18, and the copper strip is unwound at an angle of about 45° to the face of the mandrel, Fig. 19. During the process of unwinding, the small tin or burr is removed by passing the wire through a suitable die and then through a wire-drawing machine provided with three or more draw-plates to reduce the strip to the desired diameter. By employing a mandrel of 6 ft. or 7 ft. in diameter, wire 4 or 5 miles long can be made in one operation.



FIG. 19. — MANDRELS SHOWING METHOD OF UNWINDING COPPER STRIP.

Conclusion.— The advantages of an electrolytic process as compared to a smelting process are many, and the day is not far distant when copper will no doubt be leached direct from the ore and electrolyzed with insoluble anodes to produce finished copper sheets, etc., in one operation direct

from ore without any intermediate process of smelting.

The centrifugal process is a step in this direction and is at least 10 times faster than any existing electrolytic process, and a high current density can be employed without deteriorating the quality of the copper. There is no risk of lamination, as no burnishers are employed. The plant is simple and free from mechanical complications and the amount of copper locked up for a given output is small compared to other processes. The process is of interest to mechanical engineers as it conclusively proves that to get a high tensile strength in metals, combined with ductility, it is not essential to put a large amount of work into the metals as hitherto has been considered necessary by the processes of swaging, rolling or drawing, but that a very small amount of energy will suffice when applied as described.*

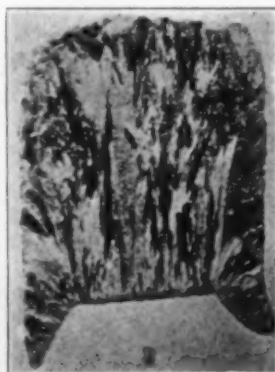


FIG. 20.—SECTION OF COPPER STRIP, SHOWING CAUSE OF CLEAVAGE.

Mixing Machinery.

By OSKAR NAGEL, Ph. D.

Mixing appliances may be subdivided into mixers for (1) solids, (2) solids and liquids, (3) liquids, (4) liquids and

*In an appendix to this paper Mr. Cowper-Coles gives diagrams representing his estimates of the savings which can be obtained with the centrifugal process in comparison with present practice. A typical analysis of the copper produced by the centrifugal process is given as follows: 0.0189 Fe, 0.0015 As, 0.0013 Pb, 0.0010 Sb, 0.0008 Bi, no Ag, no Ni, no S, copper (by difference), 98.9765. Under favorable conditions the theoretical weight of copper is said to be obtained. The cost of a plant for producing 10,000 tons of tubes, sheets and wire per year by the centrifugal process is estimated as \$670,000. The actual working cost of producing copper tubes, sheets, and wire by the centrifugal process direct from blister copper is estimated to be \$13.63 per ton. This is the actual working cost, on which there would be a further reduction of the precious metals recovered.

gases, and (5) gases. The following description is restricted to special mixing machines. Different machines, described in former articles, are also excellent mixers, for instance, pebble mills, and tube mills, which serve not only to reduce materials to an impalpable powder, but to produce a thorough mixture. For this reason manufacturers of tube mills, like the Abbe Engineering Company and the J. R. Alsing Engineering Company, also make mixing machinery. For the description of tube mills and other machines which also serve as mixers, the reader is referred to our former articles.

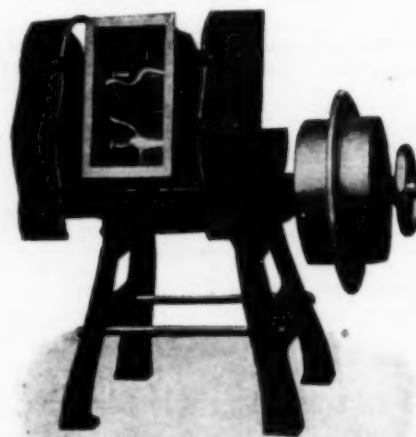


FIG. 1.—MIXER.

Very satisfactory and at the same time simple mixing machines for dry and wet solids are built by Werner & Pfleiderer, of Saginaw, Mich. Their rapidity of operation and the thoroughness of mixing account for the extensive use of these machines.

If the proper size of these machines is chosen, the most difficult mixing process can be successfully performed. It may

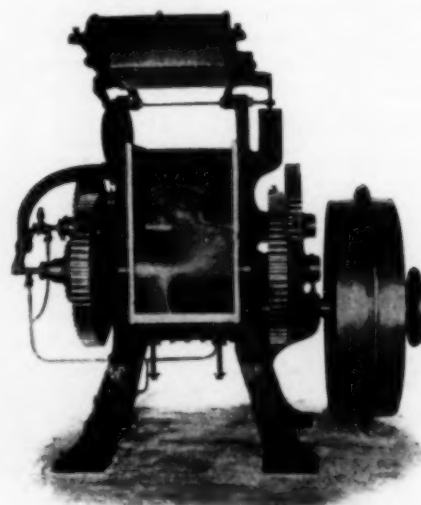


FIG. 2.—MASTICATOR.

be mentioned that these machines are used not only for mixing dry, but also wet materials. In the latter case they also act as kneading machines. The special features of these mixers and kneaders are as follows:

First, the peculiar kneading blades (mixing and kneading arms) are to be noticed; they are designed in different ways according to requirements. They revolve in two hollow half-cylinders, intersecting in each revolution successively every point on the surface of the surrounding cylinder, so that no

particle of the material can escape getting into the action of the blades.

The second feature is the reversing apparatus, by which the blades are made to revolve either backward or forward. The process of mixing and kneading is thereby accelerated and the discharge of the material greatly facilitated.

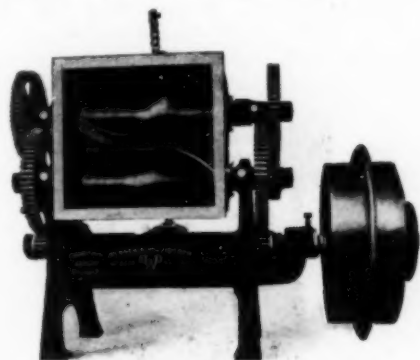


FIG. 3.—MIXER FOR HAND TILTING.

Thirdly, the troughs of the machines are shaped according to the requirements of the material to be treated, and are mounted so low that all materials can be charged and discharged conveniently.

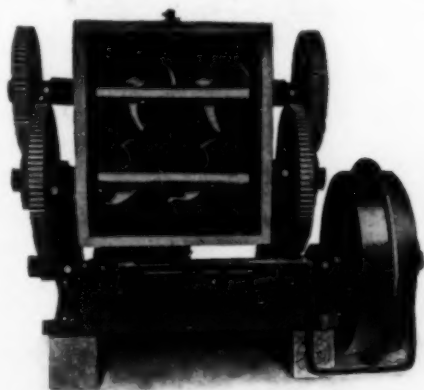


FIG. 4.—MIXER, WITH POWER TILTING ARRANGEMENT.

These kneading and mixing machines are of very solid construction, being usually built of iron and steel. For materials, however, which should not be brought in contact with iron, or for such cases in which the machines must be protected from the

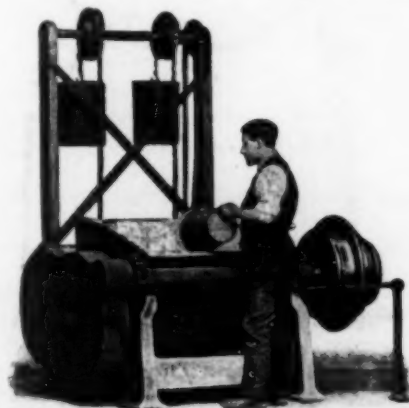


FIG. 5.—MIXER, WITH LOW TROUGH.

effect of acids, etc., the trough and blades of the machines can be zinc-plated, made of bronze or any other suitable material. For such cases in which iron must not work against iron, the blades are made of brass. In cases where the materials to be

treated exercise a severe bearing effect upon the trough blades, the trough is fitted with a movable lining and specially protected blades are provided.

The blades may be made hollow and the trough jacketed to permit heating by steam or cooling by cold water. Such arrangements are used where materials (gutta-percha, chewing

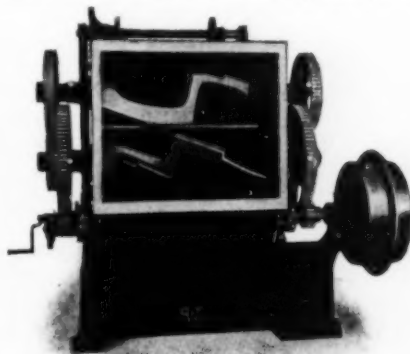


FIG. 6.—PAPER PULPING MACHINE.

gum, chocolate, licorice, etc.) require heating to facilitate the process of mixing and masticating or where cooling of the material is considered necessary or desirable.

These machines are constructed for slow as well as high speed, and also with an arrangement for two speeds so as to suit the numerous requirements of various industries. They are built in three strengths.

Class BS (gears on one side) are strong machines for kneading and mixing every kind of rubber cements, crucible paste, ointments, oils and powders.

Class BB (gears on both sides of the trough) are adapted for the manufacture of pill masses, red and white lead, stiff putty, smokeless gun powder, etc.



FIG. 7.—AGITATOR.

Classes BBB and C, the very strongest and heaviest built machines, are employed for very tough masses and for such cases in which occasionally extraordinarily sudden jerks and resistance are encountered, as with gutta-percha, india rubber, linoleum, celluloid, etc.

In the machine shown in Fig. 1 the trough can be taken apart with great ease, hence the trough and working parts can be cleaned and washed as scrupulously and perfectly as may be desired. For discharging contents it can be tilted, as shown in the cut.

The type "masticator," shown in Fig. 2, is a special construction for the kneading, masticating and malaxating of very tough masses. The trough and blades are constructed for heating by

steam; only two connections have to be made, one for steam inlet and the other for the waste steam. For cooling purposes cold water may be turned on same fittings instead of steam. In view of the great resistance to be overcome in treating very stiff materials, these masticators are very strongly built. The discharging of the material is effected by raising a flap door in front of the machine.

Figs. 3 and 4 are very rigid, all-around useful types. Fig. 3 is tilted by hand by means of a crank; Fig. 4 has a power tilting arrangement, which is set in action by a foot or hand lever. Fig. 3 can be fitted with a special device for mixing at fast and medium speeds materials the consistency of which changes during the treatment. These types are built for a capacity of 20 to 150 gal.



FIG. 8.—MIXER FOR LIGHT SUBSTANCES.

The distinctive feature of the machine shown in Fig. 5 is that the trough hangs very low in its frame, thereby rendering the charging and discharging of the machine more easy and convenient than with any of the other types. There are no steps needed and the attendant does not have to stoop to get access to the working parts inside the trough. The machine illustrated has hand-tilting gear, aided by counterweights, which makes the tilting arrangement by hand very easy and convenient. This machine, which is built in sizes ranging from a capacity of 20 to 290 gal., is also built with a power-tilting device, which is set in action by a foot or hand lever.

Fig. 6 illustrates the universal paper pulping machine built by the same concern. This machine consists of a trough with two



FIG. 9.—MIXER.

hollow half-cylinders in which revolve two agitators. These agitators intersect in each revolution successively every part of the surface of the surrounding cylinder so that no particle of the paper stock can escape getting into the action of the agitators, which tear it up and pulp it as thoroughly as may be desired.

This machine disintegrates all kinds of paper. It preserves and separates the fiber without breaking it and produces a pulp which can be made into very strong and highly finished paper.

Mixing of Liquids.—For mixing liquids preferably kettles are used which are provided with agitators. A great variety of these agitators are built by H. W. Dopp Co., of Buffalo, N. Y. In the machines built by this firm the mixers can be raised and lowered at will, which greatly facilitates removing of the contents or cleaning of the kettle. The agitator shown in Fig. 7 has an upright rack A screwed into a bracket cast on kettle. A



FIG. 10.—DOUBLE-MOTION TYPE OF MIXER.

pinion operated by hand-wheel E engages with this rack and thus the agitator can be easily raised or lowered, and on reaching the top can be swung to one side out of the way. The mixer shown in Fig. 8 is especially adapted for use of light substances, where it is desired to assist evaporation by agitation, or to keep a substance agitated to prevent burning. The

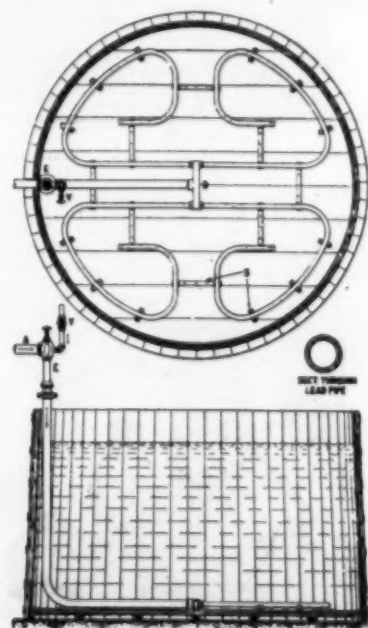


FIG. 11.—APPLICATION OF AGITATOR FOR CHEMICAL WORKS.

mixer illustrated in Fig. 9 has an additional arm conforming with the side of the kettle, from which horizontal arms project between the revolving arm of the mixer proper. It will be seen that these extra arms have a tendency to break up the substance to be mixed.

The mixer shown in Fig. 10, which is built by the same firm, is a double-motion type, i. e., both the large sweep to which are

attached the steel scrapers for keeping the sides of the kettles clean, and the horizontal paddles revolve; the latter acquire the speed of the former and in the opposite direction. This agitator is used for mixing thick substances. Various other types of agitators are built by the same company for special purposes.

Mixing of Gases and Liquids.—A very convenient apparatus for performing this operation and for stirring liquids by means of air is the steam jet blower manufactured by the Schutte & Koerting Co. The action of the steam jet agitator is based upon the fact that a steam jet issuing from a small nozzle into a larger carries along the surrounding air and gives this air a velocity sufficient to overcome a pressure of fully 8 ft. of water. The air escaping with great force from the holes in the pipe fixed at the bottom of the tank causes a violent agitation of the liquid surrounding it and stirs up and drives in all directions any solid matter or precipitates resting at the bottom.

The agitator is best placed so that its head stands above the highest level of liquid. The distributing air pipes have two rows of holes equally distributed and pointed downward. The number of these holes are fixed by the rule that the combined area should equal twice the area of the air pipe of the agitator. The diameter of holes should not exceed $\frac{3}{8}$ in.

The agitating arrangement is especially useful in chemical works, where the operation of stirring is frequently of importance. Fig. 11 shows the application of such an agitator. In this case the pipes are made of lead and rest on lead supports to give clearance between pipes and bottom of the tank, so that the air can blow against the bottom of the tank and keep the solution in circulation.

Another example for the mixing of gases and liquids is the production of sulphurous acid, as shown in Fig. 12. A is the

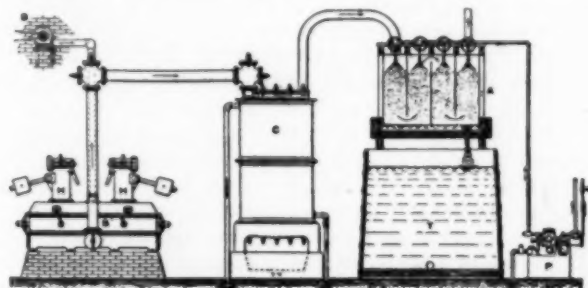


FIG. 12.—SULPHUROUS ACID PLANT.

absorption chamber with spray nozzles; B the blower for air supply; C the cooler; H the hopper; P the pumping outfit; S the sulphur furnace; T the storage tank. In this apparatus the blower forces the combustion air to the furnace, the sulphurous acid gases pass through the cooler to the absorption chamber where the gas is absorbed by the atomized water; the water pressure is operated by a pumping outfit, if there is no pressure water at disposal. The absorption chamber is so arranged that the gases have to pass up and down, being on their way absorbed by the atomized water.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special London Correspondent.)

Summer Meeting of the Institution of Mechanical Engineers.

Two papers read at Cardiff at the end of July last call for mention. That by Mr. SHERARD COWPER-COLES dealt with "The Direct Production of Copper Tubes, Sheets and Wire" (which is published in full elsewhere in this issue).

In the discussion which followed, the points raised were naturally more of a mechanical than of a metallurgical or electro-metallurgical character. For instance, Mr. E. P. Martin commented on the fact that thin sheets were cheaper to manufacture than thick sheets; another speaker asked about the tensile strength and behavior of tubes in actual place, and another

inquired as to whether bends could be made by the process. To this latter point Mr. Cowper-Coles, of course, had to reply in the negative.

A paper was then read by Mr. HUMPAGE on "The Evolution and Methods of Manufacture of Spur Gearing." Into its contents, which are of great interest and value mechanically, it is not necessary to enter in these notes. Mention must, however, be made of the discussion. A prominent motor-car manufacturer complained of the difficulty in car practice of getting the teeth of wheels the right shape after they had been case-hardened, owing to the distortion set up by this operation. It was important in the case of motor-car work that the teeth should be finished by grinding. Bevel gears in particular were troublesome in this respect, and a machine to set the teeth after they had been hardened would considerably improve matters.

Mr. Walter Deakin pointed out that a lot of trouble was due to the expansion of the cutter. When you started to work the cutter was cold, but if the metal was removed at any rate it got hot and expanded, and this gave rise to inaccuracy in the work. Something was wanted to cool the cutter or hob. A blast of air blown onto it, for example, would carry away the heat and so prevent it from expanding.

Mr. T. Clarkson first referred to the difficulty which exists in hardening hobs. He thought, however, that this difficulty would be considerably minimized with the electric furnace and suitable pyrometers. He preferred to work with non-hardened gears. He did not think grinding was necessary in all cases; in some instances, however, he believed in it. Bevels, he said, were very liable to distortion in hardening. He did not see any reference in the paper to a machine which was used some years ago for gear cutting. It had one cutter to cut any size of wheel, and it could cut internally or externally. Some years ago he had something to do with a turbine for driving a steam car. It was a De Laval turbine, and the gearing consisted of a couple of threads. He had seen the pinion running at several thousand revolutions per minute without the slightest trace of noise. He thought that this form of gearing might be used in some cases.

The Brayshaw Method of Hardening Tool Steels.

Electrically-heated furnaces in which fused salts are utilized have been employed for some little while. A new form of furnace, invented by Mr. S. N. Brayshaw, of Hulme, Manchester, is dependent upon gas or oil heating, and consists essentially of two chambers, the bottom one being slightly the larger and maintained at a higher temperature. By means of gas or oil heating the temperature of the lower chamber is raised to about 1400° C., while the upper chamber is at a bright red heat. A reducing atmosphere is obtained in the furnace by so mixing the gas and air (or oil vapor and air) before they enter the furnace that all local air currents which would oxidize the steel can be prevented.

The opening to the bottom chamber is covered by two hanging doors of fireclay securely held in iron frames. These doors slide horizontally along a bar, either together or independently. Furthermore, the bottom half of the doorway may be closed by a block which fits into it, thus restricting the height of the opening. At any moment, therefore, it is possible by simply sliding the doors to close them, either partly or wholly, and at the same time the hot side of the door is never presented to the operator, thus allowing him to work in comfort. The furnace body is of fireclay, bound with iron, and stands on an iron table.

The tool to be hardened is first heated in the top chamber to a bright red heat, and is then transferred to the lower chamber, where it reaches the very high temperature required for the best results. It is then transferred to the salt-bath furnace, which is maintained at about 690° C. The tool slowly cools to the dull red heat of the salt bath, and is then removed and allowed to cool off in air.

It is claimed that, although the tool is cooled with such extreme rapidity, yet there is no risk of breakage, the cooling

being arrested at about 690° C., and the tool comes to an absolutely uniform temperature throughout before being removed from the melt. Any stresses that may be set up by the subsequent cooling in the air are very slight and are never sufficient to cause a crack.

Market Prices, August, 1908.

Tin has undergone a sharp fall during the month, commencing at £138 10 0, it kept about this price till the 11th, being then at £138 6 0. The price fell between the 11th and 14th £6 to £132 5 0. Since then it has rallied slightly to £132 10 0.

Copper started at £60, rose to £62 by the 10th, and has since fluctuated between £61 and £60, finishing at the latter price.

English Lead is fairly steady at £14.

Hematite fell on the 7th and subsequent days, afterward remaining steady. Started 57/6, finished 56/10.

Cleveland Warrants rose from 50/- to nearly 52/- on the 10th. Have since fluctuated between 51/- and 51/10.

Scotch Pig has remained between 56/- and 56/8 throughout the month.

Chemicals:

Sulphate of Ammonia f. o. b. Liverpool, per ton.....	£4	15	0
Copper Sulphate, per ton.....	20	0	0
Caustic Soda, white, 77 per cent, per ton.....	11	2	6
Bleaching Powder, 45 per cent, per ton.....	4	5	0
Antimony, Regulus, per ton.....	£31	0	0 to 32
Shellac, Standard T. N. Orange spots, per cwt.....	6	10	0
Carbolic Acid Liquid, 97 to 99 per cent, per gal.....			11
Creosote, ordinary good liquid, per gal.....			2½
Naptha Solvent, 90 per cent at 160 deg. C., f.o.b., per gal.....			10
Rubber, Para fine, per lb.....	4s.	4	¾

SYNOPSIS OF PERIODICAL LITERATURE.

Fuels.

Analysis.—In *Eng. and Min. Journal* of Aug. 29 RANDOLF BOLLING gives some detailed methods in use in the laboratory of the Dominion Coal Company in checking up the work of the coal washers. The chemical part contains nothing new or novel. The physical test may be new. It is used to determine the work of the washers. A solution of CaCl_2 of exactly 1.35 specific gravity is prepared. Two hundred grams of coal or 100 grams of slate refuse are accurately weighed out and poured into a liter of this solution, care being taken that every particle is completely wetted. After standing 10 minutes the coal floating on top is skimmed off, washed by decantation, dried and weighed. The solution is siphoned out after each test and used over again, CaCl_2 being added to maintain the required gravity.

Charcoal Versus Coke for Blast Furnaces.—The comparison of two different fuels under so near the same conditions rarely takes place under such auspicious circumstances as that noted by R. H. SWEETSER in *Iron Age* of Aug. 13. At the plant of the Algoma Steel Company, Sault Ste. Marie, Ont., two modern blast furnaces were run for four months, one with coal and the other with charcoal as fuel. The furnaces were nearly exact duplicates of each other, one being 10 ft. higher. The ore mixture was exactly the same and, of course, climatic conditions were alike. No trouble at all was experienced in using charcoal in the 70-ft. furnace, the previous coke practice serving in running the same. Considerable less charcoal was consumed than coke for the same iron output, but one-third as much limestone was required and but 65 per cent as much blast was blown into the furnace fed with charcoal as the one using coke per ton of pig iron made.

Secondary advantages arising out of the use of charcoal as fuel were less material to handle, less blowing capacity required, less steam, less hot-blast stove area, lower blowing pressure less flue dust carried over in the gas, less cooling required in the lower part of the furnace, entire freedom from the production of a high-sulphur iron. Two thousand and eighty-three pounds of charcoal, as against 2207 lb. of coke, per ton of iron were used. The charcoal was of low grade, fuel consumption of only 1600 lb. to 1800 lb. per ton of iron produced being claimed for higher grades. The article contains a chart showing blowing conditions during the test. The failure of the char-

coal supply necessitated the use of part coke after four months, and finally the change to all coke. With the gradual replacement of the charcoal by coke the volume of the blast and the pressure of the same increased rapidly as the proportion of coke used increased. The chart shows this very clearly.

Two disadvantages of the use of charcoal as fuel are, first, the great scarcity of the same, and, secondly, the danger of ignition. The charcoal furnace required a pile of cordwood a half a mile long to supply the necessary charcoal for a day's run. Dirty, low-grade charcoal is very likely to cause numerous hangs and slips. Accompanying these is usually a large amount of fine charcoal dust thrown out of the explosion doors, it immediately igniting on striking the air, and at time the flames from such explosions reached to the ground. With clean charcoal this trouble is not so evident.

Furnaces.

Zinc Refining.—In the August number of *Brass World* a novel furnace is described for the refining of leady spelter. In general, it may be said that in the distillation of leady zinc the boiling of the metal keeps the same well stirred up and the lead is carried over probably mechanically. To avoid this stirring the new furnace is designed to heat the top surface of the bath causing volatilization from that surface without stirring up the molten mass. Opportunity is given for the lead to sink to the bottom and remain there undisturbed. The furnace is the invention of Richard Ziessling, of Grasselli. (See also the analysis of Ziessling's patent on page 381 of our September issue.)

Enamel Furnace.—In the manufacture of small quantities of high-grade enamels the crucible is the most satisfactory system of melting. However, where large quantities of enamel are needed the furnaces used are best constructed somewhat like the pots of the glass works. These furnaces when used for the fusion of enamels must have large fire places and high bridges to keep the ashes out of the melting pot. Even the draft should be sluggish to prevent the lighter particles from being carried over. In *Iron Age*, Sept. 3, drawings and description of such a furnace are given by JOSEPH VOLLKOMMER. For fusing the enamel to metals a muffle furnace must be used. Descriptions and drawings of two such furnaces are also given. Sulphur seems to be quite as big an enemy of the enameller as the iron worker. It is blamed for causing blisters on the enamelled ware. In the use of a muffle furnace with imperfect muffle in this industry an excess of oxygen must be used so that no reducing agents exist in the combustion gases, they causing blistering and discoloration of the product.

Iron and Steel.

Corrosion.—In the iron and steel industry the question of corrosion is foremost. The paper read by A. S. CUSHMAN at the Atlantic City meeting of the American Society for Testing Materials, June, is reprinted in full in the *Chemical Engineer* for August. The author's theory of electrolytic corrosion has been fully covered by us in various articles last year. (See our Vol. V, pp. 254, 257, 270, 343, 363 and 364.) HENRY M. HOWE and BRADLEY STOUGHTON are preparing a report for the same society showing that steel is less readily corroded than the purer wrought iron. They state that the presence of slag in wrought iron is no reason why it should be more resistant to corrosion than steel. The small amount present covers but little metal, and really may increase corrosion because of the difference of potential between it and the metal. (It should not be overlooked that electrolytic corrosion requires the completion of a circuit and slag is usually considered a rather good insulator, even the highly ferruginous slags of the puddle furnace.—ABSTRACTOR.) In the series of tests cited it is true that the authors show that steel is more resistant to corrosion than iron, but varied as the conditions are it seems in view of the preponderating data collected on this subject, the test cases are perhaps selected on a somewhat partial basis. R. E. HORTON in *Engineering News*, of Aug. 20, cites a new cause of corrosion. From a number of cases of corrosion which he noted,

particularly the pitting of the ends of the gates and vanes in high-head turbines, he concludes that the bulk of the trouble is due to defective design, leading to shocks and eddies in the passage of the water through the turbines.

Manganese Sulphide in Steel.—Manganese sulphide has never been considered a source of danger in steel rails, yet, according to the reprint of a paper read before the June meeting of the American Association for Testing Materials, by HENRY FAY, it may become an extremely dangerous material. A number of rail fractures were examined and this compound was found to be the cause of a great deal of the trouble formerly laid to gas and rolling flaws. Metal containing much sulphur to which manganese has been added should not be rolled at high temperatures on account of the squeezing out of this compound into dangerous plates and threads. (M. P. of MnS determined as 1162°C ., and showing considerable plasticity below that temperature). Specifications should limit more generally the amount of sulphur allowable in steel and the metal should be allowed to stand after the manganese additions to allow the MnS formed to float to the top. (In this connection the article by Geilenkirchen and Osann, printed elsewhere in this issue, on the removal of sulphur from steel in the electric furnace will prove interesting reading.)

Copper.

Alumina in Copper Blast Furnace Slags.—The behavior of alumina in the copper blast furnace has always been in question. C. F. SHELBY in *Eng. and Min. Jour.*, Aug. 8, cites the analyses of 11 slags from furnaces which have shown more or less good working, and in every case where the furnace was working well calculates the oxygen ratio of the slags, alumina included as an acid, to be almost exactly 2. Bad working of the furnace accompanies deviation from this figure. The slags were of widely varying composition: SiO_2 , 34.3 to 48 per cent; Al_2O_3 , 2.05 to 12.6 per cent; FeO , MnO , 19.9 to 37.6 per cent; CaO , 8.21 to 25.83 per cent; MgO , no to 12.9 per cent; BaO , no to 6.2 per cent. Zinc oxide seems to play no especial chemical rôle, it being either dissolved bodily in the slag as such or else in the metallic state, as is evidenced by the zinc flame and the oxide formed when the slag is tapped. This latter case is believed to lie at the basis of the fact that zinc in the charge tends to cause the slag to carry out the precious metals, they being alloyed with the zinc in the metallic state and carried out with it in the slag. The author does not believe that it is possible to replace all the silica by alumina as the slag becomes too thick and pasty. The high oxygen ratio of the Mansfield slags, 3.5, is due to the fact that they carry a large amount of alkali, a purely alkali slag with a ratio of 8 being possible.

Leaching Copper Slag.—A description of the Westby-Sorrenson process for the leaching of copper slags is found in the *Eng. and Min. Jour.* for Aug. 29, the author, E. P. JENNINGS, having been concerned in its development. Although the process is not now in use it presents some novel features which make it worth while reviewing. The process consists in passing the gas from the roasting furnaces through moistened granulated slag, the sulphur dioxide in the gas decomposing the wet slag and permitting the recovery of the copper in the same. The copper is converted into a sulphite, sulphate and thionate, and is precipitated as Cu_2S on boiling the solution of the thionates. The slag, granulated to 40 mesh, was placed on inclined shelves in a tower and moistened by allowing water to drip down from the top. The gases passed over the shelves.

The Fume Problem.—The Shelby Smelter, in California, has been experiencing a great deal of trouble with the fume question. They have recently installed the Cottrell process for condensing the fume, a description of which is published in *Eng. and Min. Jour.* of Aug. 22. The installation is reported a success. The process is essentially an electrostatic one. Two opposed electrodes are charged to a high potential by direct current and the current of gas to be purified is passed between

them. One of the electrodes is so arranged that a brush discharge takes place from its surface, the other so it does not. The solid particles in the gas touching the first surface are first electrified, then repelled into the gas current, where they attach themselves to the surrounding particles and fall to the bottom or are attracted by the other electrode. In the actual apparatus as installed, one electrode is made of wire gauze wrapped with asbestos cord and suspended inside a cylindrical iron vessel forming both the container of the apparatus and the other electrode. The gas to be purified is passed up between the two electrodes. Asbestos makes an ideal material for yielding the required brush discharge. On account of the high potential used special means must be provided for insulating the two electrodes and keeping the dust from short-circuiting them.

The same smelter recently erected a bag house, a description of which is also given in the above *Journal* of Sept. 3. Reinforced concrete was chosen as the construction material, it being protected from the corrosive action of the very moist fumes by tiling of firebrick. Three thousand eight hundred and twenty-three square feet were allowed for each cubic foot per minute of the maximum amount of gas the house would ever be called upon to filter. At the start 4,1716 sq. ft. were allowed for each of the 55,000 cu. ft. per minute of gas passing through the house. The temperature of the gas is $112-114^{\circ}\text{Fahr}$., and the fan pressure 0.625 oz. The designers now consider it safe to allow 1.14 sq. ft. of bag surface to each cubic foot of gas to be filtered per minute.

Converter Process at Mansfield.—In an article on the "Progress in Metallurgy in 1907," R. HOFFMANN, in *Chemiker Zeitung* for Aug. 15, mentions the application of the converter process to the Mansfield mattes. The process was in itself successful, but the stringent government regulations, regarding the setting free of the sulphur dioxide in the atmosphere preclude its present application. The old chamber process of converting the gas into sulphuric acid works too slow to take care of the enormous volumes of gas set free in the short time of the operation. A rapid contact method which will not clog when forced is necessary before the process can be permanently installed.

Lead and Zinc.

Silesian Practice.—The smelting practice in the zinc and lead district in Silesia is the subject of an illustrated article in the *Eng. and Min. Jour.*, for Aug. 8, by J. S. G. PRIMROSE. This district is gradually introducing the air recuperative type of muffle furnaces and discarding the Siemens regenerative type. The charges made into the D-shaped retorts consists of equal parts of roasted blende and pieces of roasted calamine and smithsonite 3 cu. in. to 5 cu. in. in size. A degassed coal is used for reducing agent. Seventy to 75 per cent represents the standard recovery. The government does not allow gases with more than 2 per cent sulphur dioxide to pass into the atmosphere. In the older plants these gases from the roasting furnaces were passed through brushwood towers through which milk of lime dropped. Trouble was experienced with contact sulphuric acid plants by the sponge clogging up, though this has lately been overcome.

Zinc Ferrites.—In the *Eng. and Min. Jour.*, Aug. 29, J. S. C. WELLS reports the result of a study of the ferrites of zinc. Compounds as basic ZnOFe_2O_3 were formed by heating mixtures of zinc and iron oxides for several hours at 800° . They are insoluble in ordinary leaching agents and may explain the cause of so many of the leaching propositions being failures when tried on commercial zinc ores.

Nickel.

Nickel Plating.—In his review of the "progress of chemistry in the year 1907, with respect to the plating industry," H. STOCKMEYER, in *Chemiker Zeitung*, Aug. 5, thinks the cause of the peeling of nickel plating is the presence of hydrogen in the same. Less hydrogen is included in plate made in a hot solution than in a cold one, and it is recommended to run the bath

Physical Properties.

Determining Hardness.—For determining the hardness of metals a new instrument is described by J. F. SPRINGER in *Iron Age*, Aug. 26. It is called the Shore schleroscope. The principle on which the apparatus is based is as follows: A hammer with peculiar shaped face is allowed to fall on a piece to be tested and the height of the rebound is measured. The apparatus is compact, the hammer being fixed in a glass tube with bulb lift and trigger release. A scale and reading glass allows of close readings of the rebound being made. A chart shows very close agreement with the Brinell method. Some determinations of hardness made with the instrument are given below:

	Compressed.	Uncompressed.
Lead	2	3
Babbitt	4-9	..
Copper	6	14-20
Zinc	8	20
Brass	12	26
Gold coin	14
Wrought iron	18	30
Type metal	20	21
Hard brass	20-25	35-40
Nickel ..	27	..
Hard brass	30	35
Steel rails (0.4 to 0.5 carbon) annealed.	26-30	..
Tool steel (1 per cent carbon and above) annealed	31-35	..
Mild steel, cold rolled	35
Tool steel (1 per cent carbon) cold roller	35-40
Gray iron, cast	39	..
Tool steel, unannealed	40-50	..
Tool steel, self-hardening	60-85	..
Tool steel (unalloyed) hardened	90-110	..
High-speed tool steel	80-105	..
Porcelain	120	..
Glass	130	..

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

Electric Furnaces.

Induction Furnace.—J. Hården, 897,203, Aug. 25, 1908. Application filed May 8, 1908. (Assigned to Grondal-Kjellin Co., Ltd.)

Fig. 1 shows the construction. The feature is the removable hearth or lining, so that when repairs become necessary, the furnace charge may be run off into a ladle, while a fresh hearth or lining is being substituted for the defective one. A is the central core of the magnetic circuit of iron; the primary coil is wound thereon. B is the bed or framework on which the furnace stands. C is the annular fusion chamber (the secondary). The hearth or lining D is built or stamped in a metallic casing E, which is independent of the other parts of the furnace and attached to the framework by bolts E. The casing E is provided with hooks F so that it can be lifted from the body of the furnace by means of a crane.

Artificially Cooled Electrode.—Fred. M. Becket, 896,429, Aug. 18, 1908. Application filed Nov. 24, 1902.

The electrode, shown in Fig. 2, consists of a carbon or graphite shell 5, and interior metallic portion 1. The latter is hollow and is artificially cooled with water. Cast iron and wrought iron are satisfactory for the metallic portion, but the most efficient metal is a ferrotitanium alloy containing 7.5 per cent of titanium. Its melting point is 300° C. above that of wrought iron and 500° C. above that of cast iron. Further, it is much tougher and less brittle than ordinary cast iron and can be easily machined. With this construction the carbon is kept cool

and preserved from exposure to air. The chief advantage of cooled electrodes is that "for the same amount of energy consumed the cost of reduction is considerably lowered. A series

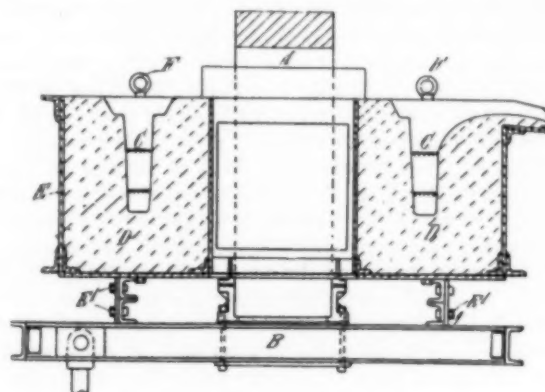


FIG. 1.—INDUCTION FURNACE.

of experiments and tests have demonstrated that in the reduction of barium carbonate a saving of over \$2 per ton in cost of production is effected."

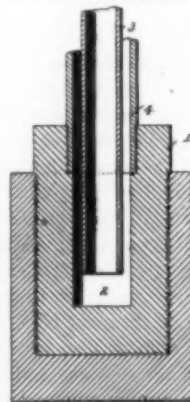


FIG. 2.—ARTIFICIALLY COOLED ELECTRODE.

If suction is employed, then, in case of a crack developing, the fused electrolyte will be sucked in and will immediately be chilled and seal the crack so that no damage will be done. The circulation of water can be easily regulated in such a way that only a thin film of electrolyte is chilled and forms a protective coating on the surface of the electrode. If the layer of chilled charge on the electrode surface becomes too thick, it acts as an obstruction.

Calcium Carbide as Reducing Agent for Ferro-Alloys.

F. M. Becket, 898,173, Sept. 8, 1908. Application filed May 25, 1908. (Assigned to Electro-Metallurgical Company.)

If calcium carbide is used as reducing agent at a sufficiently high temperature in an electric furnace for the reduction of oxide ores of chromium, tungsten and vanadium, both the calcium and carbon constituents of the carbide may be oxidized with such degree of completeness that the metallic product obtained contains less carbon than would be the case if carbon alone were used as a reducing agent. In the preparation of silicious ores the calcium oxide produced acts as a flux. In case of highly silicious ores it is necessary to add additional lime.

Electrode Renewals.—G. O. Seward and F. von Kügelgen, 898,691, Sept. 15, 1908. Application filed Feb. 21, 1906.

The production of ferrochromium and similar alloys is carried out in a continuous process, the furnace being kept full of fresh charge material to such a height at the top that the heat losses are a minimum and the carbon electrodes are cool where they emerge from the charge. For renewing an electrode, the latter is not removed (because the cold charge would fall into the cavity left and relighting of the arc would be very difficult). The electrode is left in the charge, but the holder is removed and a new length of carbon electrode is screwed onto the piece left in the charge. The holder is then connected again and a progressing feeding of the electrode is thus effected.

This method is easy with graphite electrodes, because they can be easily machined.

Electric Furnace for Distillation of Metals—J. H. Reid, 896,413, Aug. 18, 1908. Application filed Aug. 5, 1907. (Assigned to Electric Smelters, Ltd.)

The furnace comprises three chambers discharging into each other. Each chamber is provided with electrodes for producing an arc, and with nozzles for the introduction of reagents and steam, and with outlet pipes leading to condensing tanks. A vacuum is produced in each chamber by means of an exhausting fan and the metals which sublime under the action of the arc are drawn off into the condensing tanks and are condensed.

Electrolytic Processes.

Electrodeposition of Brass—S. O. Cowper-Coles, 898,189, Sept. 8, 1908. Application filed Aug. 2, 1907.

For the electrodeposition of brass, the inventor uses brass anodes together with separate zinc anodes and copper anodes, the latter being in series with adjustable resistances so as to adjust the current passing through the copper or zinc anodes separately. An electrolyte of double cyanides of copper, zinc and potassium is employed which is prepared as follows: A 10 per cent solution of cyanide of potassium is brought to the point of saturation by passing an electric current through a brass anode, the cathode being protected by a porous pot, and the electrolysis is continued as described above, small quantities of cyanide of potassium being added from time to time as found necessary.

Hypochlorite Apparatus—E. Weichert, 896,184, Aug. 18, 1908. Application filed Oct. 24, 1906.

In order to protect electrolytic hypochlorite apparatus from the effect of heat set free in the process, the author passes the electrolyte through a cooled coil made from clay arranged horizontally and situated in a cooling chamber. The upper parts of the windings discharge into chambers in which the electrodes are so arranged that each chamber has a positive and a negative pole. Each winding of the cooling coil joins two chambers, so that the solution enters the first chamber and is here electrolytically treated. It passes through the first winding of the coil and is at the same time cooled. It then enters the second electrolytic chamber, where it is again submitted to electrolysis. The solution next passes through the second winding of the coil and is thereby again cooled, and then enters the third electrolytic chamber; and so the process of electrolysis and cooling is alternately repeated until the liquid has passed through all the chambers and all the windings.

Concentrating Pickling Solution—G. W. Nistle and R. L. Gifford, 896,749, Aug. 25, 1908. Application filed June 22, 1907.

In pickling sheet iron in a solution of sulphuric acid, the acid solution becomes finally unsuitable for the process; it is then customary to neutralize all free acid by throwing scrap iron or filings into the solution and to concentrate the solution by heating it. On cooling iron sulphate crystallizes out, which is recovered as a by-product. The inventors heat and cool the solution by means of coils of brass or copper and connect these coils by an electric conductor with the basket containing the scrap iron. This arrangement represents a short-circuited galvanic cell, in which the iron basket is the anode. The neutralization of the free acid and the concentration of the solution are thereby accelerated.

Electrolytic Cell—G. C. Landis, 896,555, Aug. 18, 1908. Application filed Sept. 17, 1907.

The construction is shown in Fig. 3; the upper diagram is a horizontal section, the lower diagram a vertical section. a^1 is the inlet, a^2 the outlet for the electrolyte. The tank contains a number of units B, each complete in itself and interchangeable with any of the others. Each unit B consists of a framework

and two graphite plates, C and C', one being suspended from the top, the other from the bottom. They form a series of baffle plates, the electrolyte passing through the cell in a circuitous path, above one plate, then below the next, and so on. These plates are not connected to the external circuit, but act as intermediate bipolar electrodes. Only the two end plates d^1 and d^2 are connected to the external circuit.

Batteries.

Nickel and Cobalt Flakes or Scales—T. A. Edison, 896,811, Aug. 25, 1908. Application filed Feb. 6, 1900.

In his storage battery, Mr. Edison uses thin flakes or scales of nickel or cobalt in contact with the particles of active mass in order to reduce the internal resistance. This latest method of making these flakes is as follows: Thin nickel films are made by electro-deposition and reduced to the desired size. They are

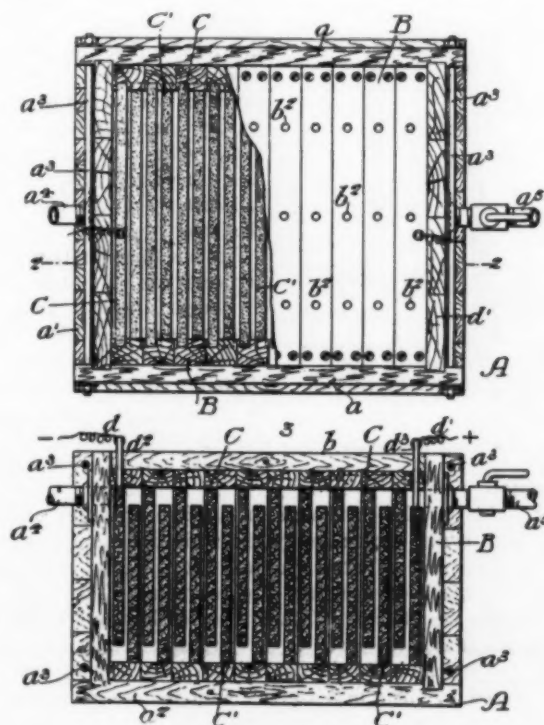


FIG. 3.—ELECTROLYTIC BELT.

then heated in an oxidizing atmosphere so as to oxidize the surface particles together with the impurities, such as iron and arsenic. The films are now reduced in an atmosphere of hydrogen and are then treated in an acid solution to leach out the impurities (for instance, in a mixture of nitric and hydrochloric acid to remove the iron and arsenic). The films thus get a rough matted surface whereby their contact with the particles of active material is improved.

Storage Battery—T. A. Edison, 896,812, Aug. 25, 1908. Application filed March 18, 1908.

"In a storage battery, a supporting plate, a plurality of tongues carried thereby and pockets secured by said tongues, said tongues being capable of being bent into such position as to permit the pockets to be separately removed from the said plate." (Claim 1.)

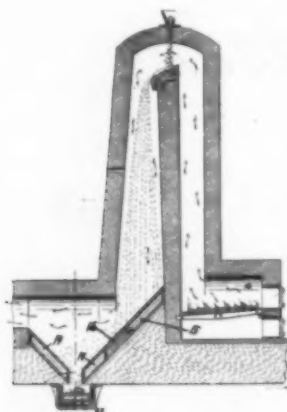
Storage Battery—L. Fiedler, 896,981, Aug. 25, 1908. Application filed Feb. 25, 1907.

The second claim refers to "a plate for secondary batteries, comprising a grid having interstices therein, said interstices being filled by molded portions of prepared lead oxide of a hard, compact and porous nature, inserted in the interstices, while in soft, pasty condition, due to the mixture of lead phenylate-acetate with lead oxide."

RECENT METALLURGICAL PATENTS.

Furnaces.

Magnetic Roast.—The report that the Dennis system of roasting, the essential feature of which is the passage of fuel gas and ore in the same direction through the furnace (our Vol. IV, page 463) is doing quite nicely in the distillation of mercury, adds interest to a method of Arthur R. Wilfley for a roast preparatory to magnetic separation, since it involves the same fundamental principle. While this method of Wilfley was already noticed in our Vol. V, page 330, his latest patent (898,024, Sept. 24) contains some further interesting details. Heretofore it has been attempted to obtain a roast of this character by dropping the ore downwardly in a shaft containing an upwardly traveling current of hot air and flame. This has resulted in overheating the finer or lighter particles of ore,



ROASTING FURNACE.

and insufficiently heating the heavier particles of ore, for the reason that the falling or downward travel of the finer particles is retarded by the upwardly traveling hot air current, while the heavier particles are of sufficient weight to fall directly downward. Hence the finer particles which require less time for roasting are subjected to the heat during a longer period than the coarser particles, thus giving results exactly opposite those desired. By causing the ore to be treated, to move downwardly in the same direction as the heat current, this difficulty is overcome; and by providing a cooling medium, preferably a water jacket, at the bottom of the shaft or roasting compartment, with which the falling particles of ore come in contact, the evil influences of excessive heat (attended by the clinging of the ore particles together) are overcome. The finer particles of ore are at once sufficiently cooled by contact with this jacket, and it is these particles that are exceedingly liable to be heated too much, while the coarser particles, though only partially cooled by their first contact with the water jacket, will be sufficiently cooled before they leave the furnace by reason of the extensive water jacketed surface with which they are brought in contact before they reach the atmosphere. It is intended to cool the entire body of ore below the roasting point before it reaches the outer air, since otherwise there would be danger to overroast the outer layer of the mass. The furnace construction is shown in the adjoining diagram. The fire box is at the bottom at the right. The hot gases pass upward around the top of the dividing wall and downward on the left together with the finely divided ore introduced at the top. The portions 15, 16, 17, 19 are water-cooled. The roasted and cooled particles of ore drop on the vibrating trough 22, which is also water-jacketed and provided with means for excluding atmospheric air from contact with the ore until the latter is fed out.

Blensing's Gases and Fumes.

Fume Arrester.—Henry Howard (896,111, Aug. 18) patents an apparatus for removing suspended solid particles from hot gases and fumes. It has two parallel chambers, each of which contains a considerable number of superposed horizontal shelves, vertical passages at the ends of these shelves serving to receive and deliver the gases by means of a valve-controlled inlet at the upper end of one passage and a valve-controlled outlet at the lower end of the other passage. The valves enable the gases to be delivered at will through either or both chambers. The horizontal shelves are, of course, intended to receive the

deposit of the solid particles. The essential and interesting feature of the apparatus is that the inlet is at the top of one vertical end passage and the outlet at the bottom of the other vertical end passage. The explanation is that an equal distribution of the gas passing through the apparatus over all the different shelves is thereby insured, simply as a result of the different specific gravity of hot and cold gases. If too much of the hot gas would flow through the upper shelves, a back pressure of hot gas would be produced in the vertical passage at the exit. This refers, of course, to the case that the gas to be cleaned is hotter to the atmosphere. Special experiments of the inventor have shown that when the gas inlet and outlet were both located at the top of the vertical end passages the efficiency of cleaning was actually less than when the superposed shelves were entirely omitted. If the object is to clean gases which are cooler than the atmosphere, the inlet must be located at the bottom of the supply passage and the outlet at the top of the discharge passage. By employing a large number of closely spaced plates, it is possible to obtain a separation of solid particles practically as complete as that effected by a filter, while the shelves offer little resistance to the flow of gases.

Copper.

Copper Castings.—In casting copper or copper alloys, the presence of oxide of copper tends to prevent the attainment of a perfectly even structure of the casting. For the same reason it has hitherto been impossible to add copper or its alloys to iron or steel in large or at least in such quantities as to impart to the metals greater hardness or strength of resistance than that of the ordinary alloys. In order to enable the addition of iron and the like, the assistance of other metals, such as zinc, aluminium or nickel, has been requisitioned, which act to a certain extent as carriers for the iron. C. Gautsch (898,638, Sept. 15) recommends the use of bicarbonate of soda. His method consists in adding to the metal—copper or mixtures of copper, tin, old metal and iron, steel or the like—besides the usual addition of phosphorus (which tends to reduce the copper oxide formed) a suitable quantity of bicarbonate of soda, a part being advantageously added right at the commencement and a part after the metal has been melted. The amount of bicarbonate of soda added may be from 1 to 2 1/2 per cent. It is stated that the bicarbonate of soda causes the mass to foam and procures an intimate mixture while the oxides of copper pass into the slag.

Hardening Copper.—H. V. Draper (896,632, Aug. 18, 1908) proposes to harden copper by melting it and adding pulverized alum and arsenic (1 lb. of alum and 4 oz. of arsenic per 20 lb. copper). After thorough stirring the metal is poured into molds.

Lead.

Lead Alloy.—G. F. Allen (807,953, Sept. 8, 1908) patents a lead alloy for which high tensile strength is claimed and which is said to be specially useful for lead pipes. It contains from 3/4 to 5 per cent of zinc, the balance being lead. The only claim, however, refers to from 1, 4 to 5 per cent of zinc.

Iron.

Refining Iron in the Cupola.—M. Ruthenburg (898,068, Sept. 8) refines pig iron in an ordinary foundry cupola by mixing it with iron ore in definite proportions (for instance, in equal quantities) and subjecting it to the fusion temperature. Two products are obtained: first, iron containing less sulphur and phosphorus than the original pig iron or ore, and, second, ferroginous cinder containing most of the sulphur and phosphorus. A mixture of equal quantities of pig iron, No. 2 Buffalo (0.75 P, 0.15 S, and 3.25 C) with iron ore (62.7 Fe, 0.6 P, 0.12 S) was treated in an ordinary foundry cupola furnace. The amount of coke used was 15 per cent of the weight of pig iron and ore. The iron obtained weighed 80.75 per cent the aggregate weight of pig iron and ore, and analyzed 0.5 P, 0.095 S, 2. C, and had a 50 per cent higher tensile strength.

A Modern Steel Foundry and Machine Shop.

By C. A. TUPPER.

The largest steel foundry of the West, for the making of general castings—viz., that of The Falk Company at Milwaukee, Wisconsin—has many features of special interest, above all the economical arrangement and operation of the works.

Foundry.

While the business of The Falk Company started in an establishment devoted especially to the manufacture of street-railway motor-gears and track appliances, and that department still constitutes an important one, a visit to the foundry and power plant is particularly interesting. The foundry is in a building 625 ft. long by 295 ft. wide at its largest part, of brick and steel construction, and has a capacity of 1500 tons monthly. Steel castings of any size required up to 40 tons capacity or more and varying widely in character, are turned as readily as is usual in the work of a smaller plant devoted to a standard line of apparatus.

To-day the custom or jobbing foundry fills so important a place in machinery-building, particularly for the production of steel castings, that manufacturers using this material are vitally interested in the facilities afforded by the various plants available to them, and it is from the standpoint of The Falk Company's customers, with one of the largest of which the writer is connected, that the following description has been prepared.

This begins with the unloading of the raw material and is designed to follow the work, step by step, through the various processes by which it progresses to the finished casting. It shows at each stage something of the equipment and system which make for the most satisfactory and reliable results—results upon which manufacturers may depend, not only during the ordinary course of business, but also in times of emergency.

Pig iron, brought in over the C., M. & St. P. Railway and left standing in cars on any one of the tracks which occupy a considerable portion of The Falk Company's ground, is unloaded by means of a Cutler-Hammer two-ton lifting magnet, at the end of a locomotive crane, and placed in piles between the tracks. An average analysis of each pile of pig iron or scrap is then taken and the magnet is again called into play to load the iron directly into charging buckets carried on small industrial trucks, which, after passing over a Fairbanks-Morse scale and having a record of the weight and contents of the buckets taken, are drawn up an incline to the charging floor of the furnaces and there lined up on tracks.

Thence they are picked by charging machines, as needed, and fed to either one of the two acid open hearth furnaces, of 15 and 20 tons capacity. The tilting hearth, supported on a heavy frame work of structural steel, forms the central portion of each furnace, and checker chambers and slag pockets are constructed at the ends, flues being provided for the admission of air in proper quantities to the combustion chamber. These furnaces, with all their accessories, were built by the Wellman-Seaver-Morgan Co. Every lot of pig iron, scrap, furnace lining, etc., is bought strictly on specifications and care is taken to see that the latter check with the analysis made by the company's chemist.

The fuel in the furnace is oil, which, after delivery in tank cars, is stored in three underground steel tanks in a concrete vault holding 15,000 gallons apiece. From those tanks the oil is pumped to the furnaces and a mixture of oil and air fed in together.

Four heats a day can be taken when required. Special heats of nickel-steel and chrome-steel castings, as well as those requiring a very high carbon content or particularly high tensile strength, are made when orders are received of sufficient tonnage, as is frequently the case.

From the tilting furnaces the liquid metal, after having the "doctor" added, is taken by four 25 to 30-ton oil-heated ladles, with bottom taps, two of which are used simultaneously, and

is carried by traveling cranes, as usual, to the various parts of the foundry where the castings are to be poured. With large molds, one of these ladles is emptied in a relatively short time. Opposite the furnaces are the core ovens, core room and temporary sand storage bins, with charcoal storage at the right. When an order is received and the patterns ascertained to be, or have been put, in proper condition to mold, the core department receives its instructions immediately, and at the same time it is learned whether the necessary flasks are available and in proper condition, so that there may be no delay on the molding floor when the men are ready to take up the work. This might be taken as a matter of course; but in a custom foundry, especially, where the work varies so much, it requires the best of system to keep the flasks in order and properly mated. Failure to do so, often means delay and sometimes serious loss to the customer.

After coming from the ovens the cores are closely inspected and any defects at once remedied. The core frames, as in all good foundry practice, are so constructed as not only to support the cores while they are being baked, but also form part of the trucks used to transport them from one place to another.

The loam and dry sand molding is done in a part of the foundry distinct from the green sand floors.

The foundry, which has been built with high head room, is built by Pawling & Harnischfeger, of Milwaukee. Two of these have an 80-ft. span, with a capacity of 50 tons each; five are 50-ft. cranes designed to carry 30 tons each, and there is one of 25 ft. span rated at 10 tons. All of the cranes have large overload capacity. Jib cranes, telephers and tracks running throughout the yard and shops complete the transportation system.

The various floors of this plant are provided with a thoroughly up-to-date foundry equipment, including special machines and mechanical appliances of the latest design. Among them are molding machines of the "power squeeze" and "hinged" types manufactured by the Tabor Manufacturing Company of Philadelphia, designs of the Pneumatic Machine Company in Zelienople, Pa., the Rowlands Machine Company's adjustable table pattern and rollover, straight-drop style of E. Killing's Molding Machine Works in Davenport, Iowa; pneumatic hoists built by the Curtis & Co. Manufacturing Company of St. Louis, and Pawling & Harnischfeger of Milwaukee; cold cut-off saws furnished by the Espen-Lucas Machine Works and the Newton Machine Tool Works, both of Philadelphia, the former of which are equipped with Disston inserted tooth blades and the latter with Taylor-Neubold blades; sand mills with shelf-discharging pans, built by Thomas Garlin's Sons Company of Pittsburg; pneumatic shaker screens and riddles of the design of the Hanna Engineering Works of Chicago; machines for straightening core wires or gagers purchased from the J. D. Smith Foundry Supply Company of Cleveland; hack saws and tumbling barrels of The Falk Company's own make, the latter for use in cleaning the smaller castings; crucible outfits, bench tools and other types of modern machinery for producing and handling a large output to the best advantage. Until recently there has probably been no branch of the metal trades industry in which so little was done, as in founding, to assist the skill of the workmen by mechanical appliances; but this condition is rapidly changing and The Falk Company has been one of the pioneers in bringing about an improvement.

To properly clean castings is as essential as to properly mold them, and the facilities afforded here for this work are of the best. After the castings have cooled they are taken by cranes, if large, or on rail-tracks, if small, directly to the cleaning department, which is an 80-ft. integral extension of the main foundry, 155 feet wide, and is fitted throughout with pneumatic devices, such as hoists, chipping hammers, sand blasts, surface-grinders of the swing frame type built by the Safety Emery Wheel Company and saws of various sizes capable of removing heads ranging from those of the smallest dimensions to weights of two to three tons or more. At one end is a sand blast room

with an exhaust fan in the side to draw off the flying dust. Compressed air for this and the other departments is brought in direct pipes from a main duct which runs to the center of the foundry in a straight line from the power plant. In this connection it is of interest to note that The Falk Company has obtained particularly economical results in the production of air by means of two-stage compression. The single stage



FIG. 1.—OPEN-HEARTH FURNACES AT FALK CO. PLANT.

machine in the power plant is only used as an auxiliary. Both are of Allis-Chalmers Company's build.

Waste is, of course, carefully looked after. All of the sprue and overplus, are collected each night, if not oftener, and taken directly to the scrap piles in the yard to be melted over again with pig.

Adjacent to the foundry and served by a 20-ton crane built by the Industrial Works, Bay City, Mich., are two annealing furnaces especially designed and built by The Falk Company, of sufficient size to admit the largest castings and so constructed as to obtain an evenly applied heat throughout, thus assuring uniformity in the texture and general quality of the castings. The tops of the trucks upon which castings are run in to the furnace form the principal part of the floor. By means of constant experiments and tests the annealing in these furnaces is kept at a high state of efficiency.

The floor of the foundry is lighted in the day time by side windows and a monitor extending the entire length of the building, which has ventilator windows on each side. At night,



FIG. 2.—STOCK ROOM.

arc lamp illumination is used. The height of the building is such as to give ample space for the gas, smoke and steam to rise and pass off through the ventilators.

The shops are heated in winter by means of the National Blower Company's system, which consists of forcing hot air through pipes running along the top of the building.

Sand is kept in sufficient supply to dry naturally before being

used and it is carefully selected and mixed, the grades adapted to each class of work being kept separate. Temporary storage bins are placed at one end of the molding room and the main supply kept under cover in a frame structure near the railroad tracks, where brick and furnace linings are also kept.

Unusually successful results have been obtained here by the use of electric welding, which, only a few years ago, was regarded with suspicion. Bars welded by this method have stood tests of tensile strength on a Riehle testing machine (Fig. 3) up to 58,000 lb. per sq. in. This, however, is not necessarily indigenous to the system itself, which like any other system of welding, is capable of misuse, but has been brought about by constant experiment and observation of working results.

From one to another of the various operations the work is so laid out and arranged that every man does just what he has been employed to do; for example, molders actually mold and do not perform such operations as pulling out castings, taking care of the bottom boards, wetting down the sand, "cutting-over," etc., which can be done just as readily by assistants or laborers whose pay is much less. The molders are also relieved

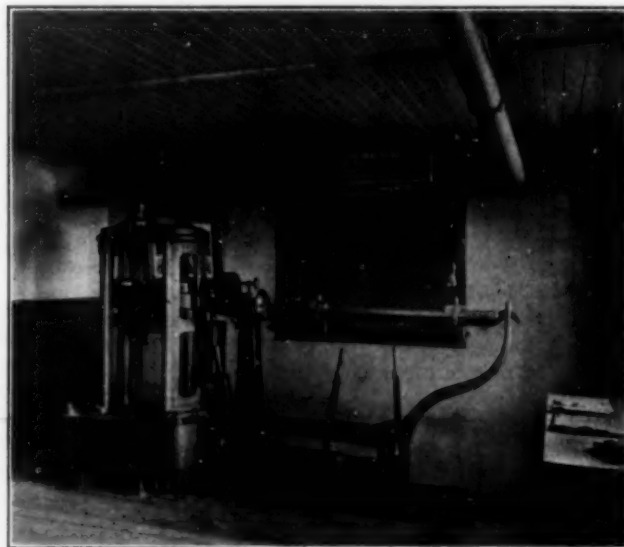


FIG. 3.—RIEHLE TESTING MACHINE (200,000 LB. CAPACITY).

from participating in or superintending the pouring, there being a special pouring gang for this purpose.

As a necessary adjunct to the foundry, The Falk Company maintains its own chemical testing laboratories, which, like all the plant, are thoroughly modern in equipment.

The testing laboratory has a Riehle testing machine of 100 tons capacity, a LaChatelier pyrometer, a Siemens water pyrometer, and a full set of microphotographic apparatus. This enables The Falk Company to secure a complete and minute record, physical and chemical, of all material used in the furnaces and of the resultant castings.

At one side of the works is an emergency hospital, where immediate surgical and medical aid can be rendered in case of accident.

Patterns.

Lumber for use in the pattern shop is thoroughly seasoned and a large quantity kept constantly on hand, as the importance of using material in the proper condition for castings, thereby insuring against shrinkage or distortion, is not to be overestimated in steel foundry practice.

The Falk Company makes a specialty of turning out patterns for customers, particularly for duplicate work or that of an intricate nature requiring special care in shrinkage measurements.

All patterns made in The Falk works or received from the outside are carefully numbered and placed in a steel-frame con-

crete pattern storage building, well arranged with shelves and partitions, where a card record of them is kept. A very elaborate system has been evolved for keeping orders and checking up daily all the work done, and a complete card index of the patterns is kept.

The pattern shop is equipped with wood working machinery of the latest type, the principal part of which was furnished by

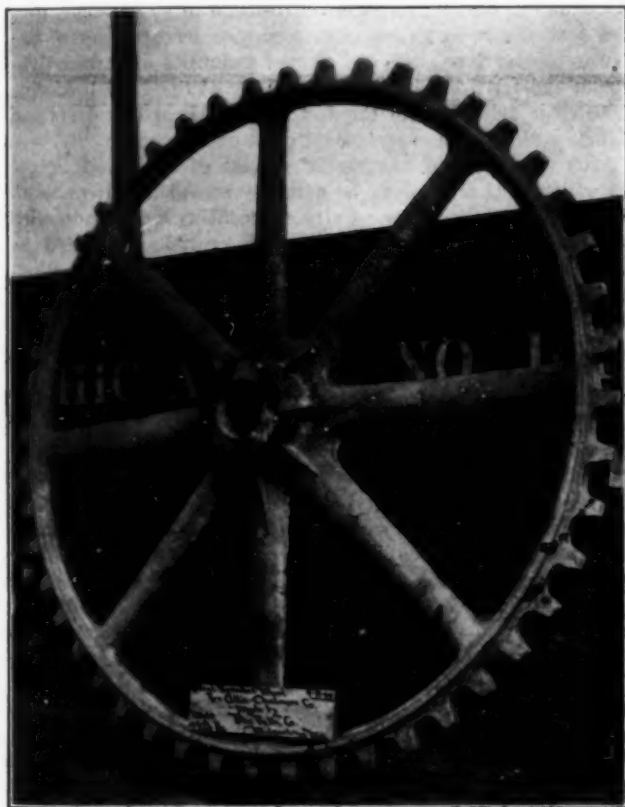


FIG. 4.—LARGE STEEL SPROCKET WHEEL MADE BY FALK CO. FOR ALLIS-CHALMERS CO.

the Oliver Machinery Company, together with the Fox Machine Company, both of Grand Rapids, the Security Machine Company of Chicago, and the Rowley-Hermance Company of Williamsport, Pa. A very interesting tool used in this department is also one for cutting gear pattern teeth, which is built by The Falk Company itself.

Railway Department.

The railway department of The Falk Company, which now serves street and interurban traction companies, as well as steam roads, turns out cast steel gears and forged steel pinions; girder rail and high T sections for city railways; low standard sections of from 56 to 100 pounds for steam and interurban lines, and a great variety of special work. This department has an exceedingly well-equipped machine shop, including planers and lathes furnished by the Niles-Bement-Pond Co. of New York, the American Machine Tool Company and the Lodge & Shipley Machine Tool Co. of Cincinnati; drilling and boring machines of the type manufactured by Pawling & Harnischfeger of Milwaukee; gear cutters of Gould & Eberhardt of Newark, N. J.; drills of Prentice Bros. Co. of Worcester, Mass.; Bryant milling saws of Henry Disston & Sons, of Philadelphia; key seaters of Mitts & Merrill, Saginaw, Mich.; milling machines built by the Kempsmith Mfg. Co., and Kearney & Trecker Co., both of Milwaukee, the former having special feed changing and tripping mechanism; boring mills of the Colburn Machine Tool Co. of Franklin, Pa.; draw cut shapers of the Morton Mfg. Co. of Muskegon Heights, Mich.; grinders of the Brown & Sharpe Mfg. Co. of Providence, R. I., and of the

Safety Emery Wheel Co. of Springfield, Ohio; rail saws furnished by the Railroad Supply Co. of Chicago; expansible reamers of a new type, designed and built by The Falk Company; hydraulic presses, with accumulator and pump built by Logemann Bros. of Milwaukee, the latter direct-driven by an Allis-Chalmers type "K" motor, and some very efficient and accurate pinion cutters of The Falk Company's own manufacture.

In the forge shop are three steam hammers built by the Niles-Bement-Pond Company of New York, two of 1500 lb. and one of 1000 lb. capacity, together with blowers and forges of the Buffalo Forge Company of Buffalo and a full complement of forging tools. The heating furnaces are of standard design. In this shop are produced monthly thousands of forged blanks for street railway motor pinions.

The most popular types of frogs, switches, etc., made by the company for street railway service are the hardened center manganese insert and the solid cast steel types. The special feature of the former is the binding of the separate parts together with the plates by a mass of open-hearth steel, producing an integral structure. This feature is also carried out in the construction of hardened center railroad crossings. All wearing points and surfaces, such as frog and mate points, with running surfaces in their proximity and near the points of tongues, are

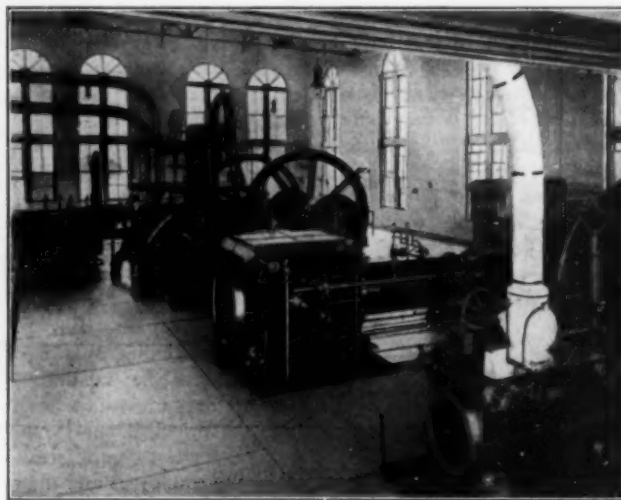


FIG. 5.—PART OF POWER PLANT OF FALK CO.

especially hardened by The Falk Company's own process, and, being integral with the main casting, there are no parts to become loose.

The steel-bound-integral type of construction is also one now being largely turned out by The Falk Company. This overcomes the objection to the bolted construction by eliminating all loose parts. The individual pieces are firmly bound together by a steel casting, which, in frogs, is so designed as to give protection to the frog points. The use of steel of high carbon and manganese composition insures a durability not obtainable with the gray iron ordinarily used. To small and growing systems, not desiring to purchase the more expensive high-grade hardened center work, but wishing for something better than the built-up type, the steel bound fills the want. However, built-up "regular" special work still holds its own with the smaller lines and the system which, being a fast-growing one, requires constant changes by reason of increased traffic, new extensions and consequent re-routing of lines of operation.

One feature of The Falk Company's railway work, which is now so well known as not to require extended mention, is that of cast welded joints for lengthening the life of old rails.

Power.

All of the machinery in the entire works of the company, which does not take compressed air, is electrically operated, principally by individual motor-drive, although short lines of

shafting are used in such places as the pattern shop, cleaning department of the foundry, etc., where numbers of light running machines make this arrangement the most advantageous. Electric current and compressed air are supplied from a new central power station which is one of the most interesting features of The Falk Company's works. Neatness, orderly arrangement and absence of a large percentage of the usual quantity of piping, are points which strike the visitor's attention immediately upon entering; but, as the station design is followed out it soon becomes apparent that these are only an index to the general character of the plant, which was equipped, in all its main details—engines, generator, compressors, circulating pumps, etc.—by the Allis-Chalmers Company, of Milwaukee.

The machinery consists of a cross-compound condensing Reynolds-Corliss engine, operating at 100 r.p.m. and coupled to a 550-kw generator, delivering direct current at 250 volts; a simple condensing Reynolds-Corliss engine of the vertical pattern, direct connected to a 125-kw generator with characteristics similar to the larger machine; and two air compressors, one two-stage and the other single-stage, having capacities of 2500 and 1800 cu. ft. of air per minute.

In the steam generating room are three Wickes vertical water-tube boilers designed for a working pressure of 150 lb. and rated at 300 hp each, with furnaces and grates of the same builders' standard construction.

The switchboard was built by Geo. F. Rohn, of Milwaukee, and equipped with standard apparatus, including the Cutler-Hammer switches. The distribution of current to the shops is through insulated underground cables, which feed a network of wires run in iron piping to the various departments where power is needed.

The plant is thoroughly equipped with modern appliances for conducting efficiency tests and gathering daily records, all of which are kept in constant service, and this has a very appreciable effect upon the operating economy.

As The Falk Company started at its present site in 1899 with a plant extending over less than a quarter of an acre, and the present works have now an area of 50 acres, including a covered floor space of nearly ten acres, it is apparent that conditions leading to the rapid expansion of the business must have been uncommonly favorable. Among these the principal one is undoubtedly the management of the works themselves, an interesting feature of which is the treatment of the employees and their relation to the officers and heads of departments. All of the men in the plant, including not only those who occupy responsible positions, but also the great majority of the skilled pattern makers, molders and laborers, have been trained here to the positions which they now occupy. It is a recognized principle, well exemplified here, that to successfully handle men those in authority must be leaders rather than drivers. The plant is run strictly as a non-union shop; consequently there is no check upon individual ambition and ability.

In the office building, which is a two-story pressed-brick structure fronting the works, the same system and good order are observable as in the shops. One very interesting detail of The Falk Company's organization is its purchasing system, which has here been literally "reduced to a science."

The Falk Company's reputation as steel founders is now widely diffused through the country. It has demonstrated its ability to produce satisfactory castings, not only of a general character, but also those of the most difficult kind, some of which other foundries have failed to make successfully. In this way it has established itself with the largest and most particular users of steel castings in America, and the business is now operated upon a basis which cannot fail to make for continued prosperity in the future.

The officers are Herman W. Falk, president; Otto H. Falk, vice-president; Charles L. Jones, second vice-president; E. A. Wurster, secretary and treasurer; Clarence R. Falk, works manager; Harold Falk, general superintendent, and W. Frank Carr, chief engineer.

The Girod Electric Steel Furnace.

In our January issue, 1907 (our vol. V, p. 9), Dr. R. S. Hutton gave an interesting review of the activity of the Société Anonyme Electrometallurgique, Procédés Paul Girod, which has three important works in operation in Europe, viz., at Ugine in Savoy, at Courtepin and at Montbovon, in Switzerland. The magnitude of these works is indicated by the following figures of the annual output; 5000 tons ferrosilicon of 50 per cent, 1000 tons ferrosilicon of 30 per cent, 2000 tons ferrochromium, 800 to 900 tons ferrotungsten, and smaller quantities of ferromolybdenum and ferrovanadium. The rapidity of the growth of this industry is evident from the fact that M. Paul Girod started in 1898 with a small experimental plant of only 28 hp.

After this splendid commercial success of M. Girod in the manufacture of ferroalloys, he naturally turned his attention to steel making and refining. Early experiments were made with a furnace, consisting of a refractory crucible embedded in granular carbon which acted as resistor (described and illustrated in our vol. II, p. 309). The furnace was, therefore, a plain resistance furnace and the method of operation was essentially that of the crucible process, the only novel feature being the heating of the crucible electrically by means of a carbon resistor. Naturally M. Girod could make in this furnace high-grade steel of crucible-steel quality, but he recognized soon that this type of furnace did not exhaust the economical possibilities of electric steel making. As noticed in Dr. Hutton's article, this type of furnace was, therefore, abandoned for steel manufacture and M. Girod turned his attention to the development of a furnace which would combine arc and resistance heating, and in which the steel bath itself would form the resistor.

The advantages of the arc furnace for steel making are well known from the process of Dr. Héroult in which two carbon electrodes are used above the slag which covers the steel bath. The arcs play between the ends of the carbons and the slag and the two arcs are in series, the two carbons being of opposite polarity. The electric current passes from one carbon into the slag, and through slag and metal bath, and out of it into the other electrode. The furnace is essentially an arc furnace. Almost the whole heat comes from the arc, only a few per cent of the total heat being Joulean heat.

While the new Girod furnace is similar in external appearance, it is essentially different in so far as the carbon electrodes at the top are all of the same polarity, whatever their number, while the other pole is provided in the bottom of the furnace. All the electrodes at the top are therefore in parallel. The electric current passes from these electrodes into the slag, then into the steel bath, and leaves through the bottom. The slag and the steel bath represent two resistances in series and the furnace is a combined arc and resistance furnace. Naturally it is not necessary that there are two electrodes at the top. For furnaces of small size one electrode is sufficient.

The fact that there is only one arc on top of the bath (or several in parallel, but not in series) has the following advantages. It permits easier automatic regulation, because the difficulties of regulating two arcs in series are overcome. Further, the voltage is reduced to one-half that required with two arcs; the Girod furnace is operated practically at 50 volts. This results in a very easy method of providing thorough insulation and greatly reduces the risks to workmen. Naturally for the same power, the conductors to the furnace have now to carry a correspondingly increased current and must therefore be made thicker. The fact that the whole current must pass through the charge, facilitates greatly the starting with cold charges.

The furnace is formed by a sheet-steel framework of circular or rectangular section, lined with magnesia. A charging and working door, and also a top hole, are provided in the walls. The steel is tapped by tilting the furnace, which is therefore mounted on pivots or on a cradle.

The roof is made from silicon brick built around cast-iron

pieces with inside independent water circulation, through which pass the electrodes. The electrodes are adjusted in such a manner that the air cannot enter into the furnace; this adjustment, and the use of the cast-iron parts, are rendered possible by the fact that there are no electrodes of different polarity at the top so that there is no danger of a short circuit through the cover.

The automatic regulation of the electrode is either voltage regulation or current regulation. For furnaces of small capacity, say 2 tons, only one electrode is used at the top; if such a furnace is supplied with energy directly from a generator, voltage regulation is employed; i. e., the regulating mechanism tends to keep the voltage constant. If the furnace is supplied

with energy from a transformer or if there are several electrodes (in parallel) at the top, current regulation is used, i. e., the regulating mechanism tends to keep the current constant.

The steel bath reaches a height of from 25 to 30 cm in the bath. As explained before, the bottom of the hearth acts as an electrode. For this purpose several soft-steel blocks are embedded in the hearth and are in direct contact with the molten metal. Of course, there is a tendency of the upper parts of these lower pole pieces to become molten at their extreme ends. But practice has shown that they do not decrease by more than 5 or 10 cm in length in several months' work. With a view to counteracting this tendency and preserving the lower lining of the furnace intact, the extreme lower end of the pole pieces are water-cooled. A cavity about 150 mm deep is provided for this purpose in that part of the piece which projects outside of the furnace frame; this projection is also connected with the external circuit.

The process of steel making and refining in the Girod furnace is in its metallurgical aspects quite similar to electric steel treatment in general. A period of decarbonizing with oxidizing slags is followed by removal of phosphorus and sulphur by

means of basic slags and recarburization to the desired degree. This subject is discussed at great length in an article on the removal of sulphur in electric steel furnaces, published elsewhere in this issue.

The consumption of power per ton of steel produced is from 800 to 900 kw-hours at the terminals of the furnace; therefore, allowing for 10 per cent loss in the conduits, a consumption of about 1000 kw-hours per ton at the generator can be reckoned on, it being understood that a steel of superior quality is being

produced from unsorted iron and steel scrap of the cheapest kind.

In the case of merely smelting a charge of a given composition as in the crucible furnace, the consumption may vary between 650 and 750 kw-hours, but then the extra cost of the raw materials exceeds the saving in power. The final composition of the steel likewise plays an important part in the number of kilowatt-hours consumed per ton.

These figures of consumption were obtained in the operation of the Uginé furnace of 275 kw, which has a capacity of 1800 kg. In furnaces with a greater capacity the consumption in kilowatt-hours per ton of steel smelted and refined or only melted diminishes to a considerable extent.

Should liquid steel from a Martin or Bessemer furnace be charged into the electric furnace it would be necessary to expend 350 kw-hours per ton for refining and giving the exact quality to the metal in the 1800 kg electric furnace. This consumption may be diminished to about 250 or 300 kw-hours, according to the capacity of the furnace and the nature of the product to be refined and obtained.

The cost for consumption of the electrodes when starting with scrap as raw material amounts to about 5 francs (one dollar) per ton of steel produced. When refining a liquid charge, it becomes as low as 2 francs (40 cents) per ton of steel.

For the management of a 3-ton furnace a melter, an assistant and a boy are necessary.

The adjoining illustration gives the drawings of a 2-ton 300-kw furnace, with only one electrode at the top. Furnaces of larger capacity are provided with more than one electrode at the top, all being in parallel.

Messrs. C. W. Leavitt & Co., of New York, are the representatives of M. Girod in this country.

A New Electric Pyrometer.

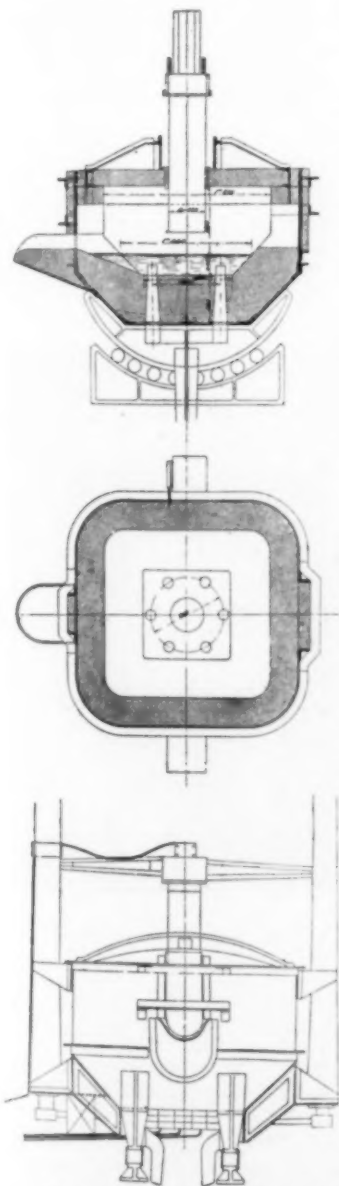
A new electric pyrometer has been placed on the market by Edward Brown & Son, 309 Walnut Street, Philadelphia, Pa., which approaches the accuracy of the Le Chatelier pyrometer, but which can be subjected to the roughest kind of usage and can be supplied at a moderate price.

The Brown electric pyrometer consists, in the stationary form, Fig. 1, of a large-size switchboard type millivoltmeter for indicating the temperature, a thermocouple which is inserted in the furnace the temperature of which is to be measured, and the



FIG. 1.—STATIONARY TYPE OF INDICATOR.

leads or wiring for connecting the thermocouple to the indicator, which may have practically any length desired. The extra large millivoltmeter used with this instrument is particularly desirable, as the scale graduated in temperature degrees is exceptionally long with large figures, which can be easily read at a distance by a workman. Where a portable instrument is re-



TWO-TON GIROD STEEL FURNACE.

quired, which can be readily carried about, a portable indicator is supplied, such as illustrated in Fig. 2.

The thermocouple is part of the pyrometer which is inserted in the furnace or other room, the temperature of which is to be measured.

For measuring most temperatures which are not excessive, the thermocouple is constructed of heavy nickel alloy and tungsten alloy wires, having a fusing point of 2700° Fahr.

This form of couple is, however, not recommended for tem-



FIG. 2.—PORTABLE PYROMETER WITH THERMOCOUPLE.

peratures as high as this, the platinum-rhodium thermocouple being much more durable and constant in its indication at such high temperatures.

The wires of the thermocouple are insulated by small fire-



FIG. 3.—THERMOCOUPLE IN STEEL TUBE AND ADJUSTABLE FLANGE. FIG. 4.—THERMOCOUPLE AND STEEL TUBE PROTECTOR.

clay tubes and mica washers, serving to hold the wires in the center of the protecting tube.

The great advantage of this insulation is that it will stand 3000° Fahr. or 1600° C. without damage, and is besides quite inexpensive.

For protecting the thermocouple, steel tubes are used in most cases up to 1600° Fahr., while for temperatures above this tubes of porcelain, quartz, firebrick and graphite are preferable, and each form of tube has its advantages for certain uses.

Where instantaneous temperature measurements are required as is the case with molten metals, an unprotected thermocouple is supplied, heavy in construction, and especially designed for quick readings.

A very advantageous feature of the electric pyrometer is in the ability to connect a number of thermocouples to one indi-

cator by means of a switchboard. By turning the handle of a switch to any of several numbered points, the temperature of any of the furnaces or metal baths, correspondingly numbered, can be read off on the indicator. The switchboard, supplied with the Brown electric pyrometer, works on the knife-switch principle, which is absolutely positive in its action and with which poor contacts cannot occur. It has the advantage over the knife switch in that only one handle has to be turned to any of the numbered points, and it is impossible for more than one thermocouple to be thrown onto the indicator at a time, which could readily occur with a number of knife switches in a row.

In blast furnace practice, a thermocouple especially designed for this use, is inserted in the bustle pipe, also one in the top of the dust-catcher for gas temperatures, and these can either be connected to individual indicators or to one indicator with a switchboard, and a recorder can also be connected to the same couples to record the temperature in the superintendent's office.

This pyrometer has also proven very desirable at blast furnaces with iron stoves, one couple being used for each stove, one on the bustle pipe and one on the dust-catcher, and all connected to a switchboard and indicator.

In annealing, hardening, tempering, etc., the pyrometer has proven of the greatest advantage whether this is done in coal,

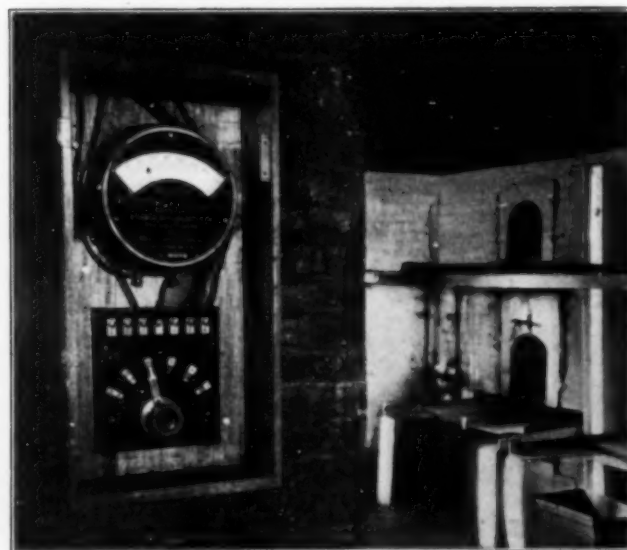


FIG. 5.—COMPLETE INSTALLATION OF ANNEALING OVENS, SHOWING OVENS IN THE DISTANCE.

oil or gas-fired furnaces, or in metal baths using lead, barium chloride or any other salt.

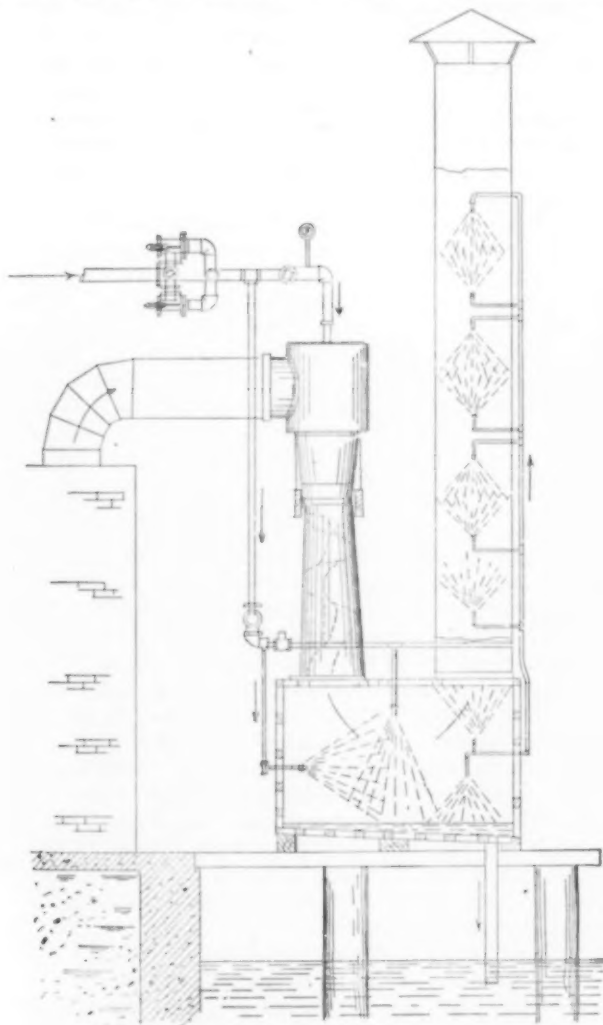
Tinning and galvanizing require very accurate temperature measuring instruments, and with this pyrometer 20 tinning pots can be connected to a switchboard and indicator in the superintendent's office at very moderate cost. He can thus find out the temperature of every pot in the tin house in a few minutes and without leaving his office.

In glass works probably the highest temperatures are met for any great length of time, and the Brown electric pyrometer is at present in use, week in, week out, on glass-melting tank furnaces at 2750° Fahr. When checked up with a portable Le Chatelier pyrometer no error has been found in their readings. A pyrometer which will stand such severe conditions is naturally very desirable for measuring the ordinary temperatures usually found in ordinary industrial works, where a practical pyrometer is needed of low first cost and little expense for maintenance when placed in the hands of the workmen.

Mercury Mine.

The Black Butte quicksilver mine in Lane County, Oregon, 150 miles south of Portland, is one of the most extensively developed mercury mines of the present day in the United States. The vein is 400 feet wide, and has been opened for over a mile along its course and down to a depth of 1600 feet below the apex of the mountain. There are more than 16,000 feet, or over three miles, of tunnels, raises, etc.

The mine is of principal interest, however, on account of the distillation process employed, which is a new departure in metallurgy. Mr. W. B. Dennis, the manager of the mine, is the inventor. Since the process was described in detail in our Vol. IV, page 463, we will repeat here only the essential features.



VAPOR EXHAUSTION AND ABSORPTION PLANT.

The fuel gas (producer gas) passes through the roasting furnace in the same direction as the ore is moved. The whole furnace is divided into a number of zones, and the temperature slope between the ore and heat current in each zone is adjusted and regulated according to the special conditions of each zone. The fuel gas made in the gas producer is not supplied in bulk at once at the cold end of the furnace, but is gradually supplied to each zone, together with enough air, according to the conditions prevailing in each zone.

Compared with the old-type mercury-ore roasting furnaces, the Dennis furnace is stated to have shown the following principal advantages in a long series of tests:

Reduction of the roasting period from 36 to 4 hours.

Increase of capacity over the old types of furnaces in the ratio of 6 to 1.

Complete elimination of all soot and smoke, thereby putting a stop to losses through the smokestack, and doing away with the expense and incident loss of re-handling condenser products.

Entire elimination of all danger to workmen, and of the detrimental effect upon the surrounding country from escaping smokestack gases.

Clear running quicksilver in the condensers and very greatly increased ratio of recovery.

The entire elimination of all values from the flue dust and therefore of the losses and expense of re-handling dust chamber products common to other types of furnaces.

Complete reduction of all values in one operation, with no residue from any portion of the process requiring re-treatment.

Vapor Condenser.

The Schutte & Koerting Company, of Philadelphia, have developed a new vapor condensing outfit for eliminating the smell in fertilizer plants, packing houses, etc., especially in connection with driers where the fertilizer material is treated. The great advantage of this system, which is proving very satisfactory in practice, is that the force of the water creating the draft in the water-jet exhauster is utilized at the same time to condense the vapors; in that way one of the operations is free to the user. The plant which is shown in the adjoining diagram works in the following way:

The water-jet exhauster working with water pressure of 80 lb. creates a vacuum and sucks the vapors from the drier, or from a room where the obnoxious gases are, and presses them through a scrubber to the atmosphere. The scrubber is equipped with spray nozzles of the Koerting centrifugal type, which take care of the rest of the fumes which might have passed the exhauster. The arrangement not only takes care of the odors and eliminates the same, but also increases the output of the drier on account of the draft created.

The Schutte & Koerting Company have installed a number of plants to entire satisfaction, for instance, I. P. Thomas & Company, Paulsboro, N. J., and the Alpha Process Company, Wilmington, Del., and are now installing one for the Seacoast Canning Company, Eastport, Maine, and A. W. Dodd & Company, Gloucester, Mass.

Oxygenite and Its Use in Antogenous Welding.

We have had occasion to refer repeatedly to the pioneer work of the Industrial Oxygen Company, of New York City, in introducing to this country the process of antogenous welding by means of the oxy-acetylene flame. It is now being generally recognized that a welded joint is in every respect superior to a riveted joint. Further, the Industrial Oxygen Company has so perfected all the details of the oxy-acetylene blow-pipe and accessories that an ordinary workman is easily able to do efficient welding work with but little practice.

To meet the requirement of producing oxygen gas at the spot where and when needed, this company has now placed on the market a new product called oxygenite. "Oxygenite is a special product in powder form, somewhat resembling fine gray sand; possessing the remarkable property of liberating the oxygen it contains when burned in a closed vessel; giving off about five cubic feet per pound, and at the same time storing itself under a pressure of from 150 to 200 pounds, according to the capacity of apparatus used, without the aid of auxiliary compressor or power. It is practically impervious to moisture, and therefore does not deteriorate to any extent, even from constant atmospheric exposure."

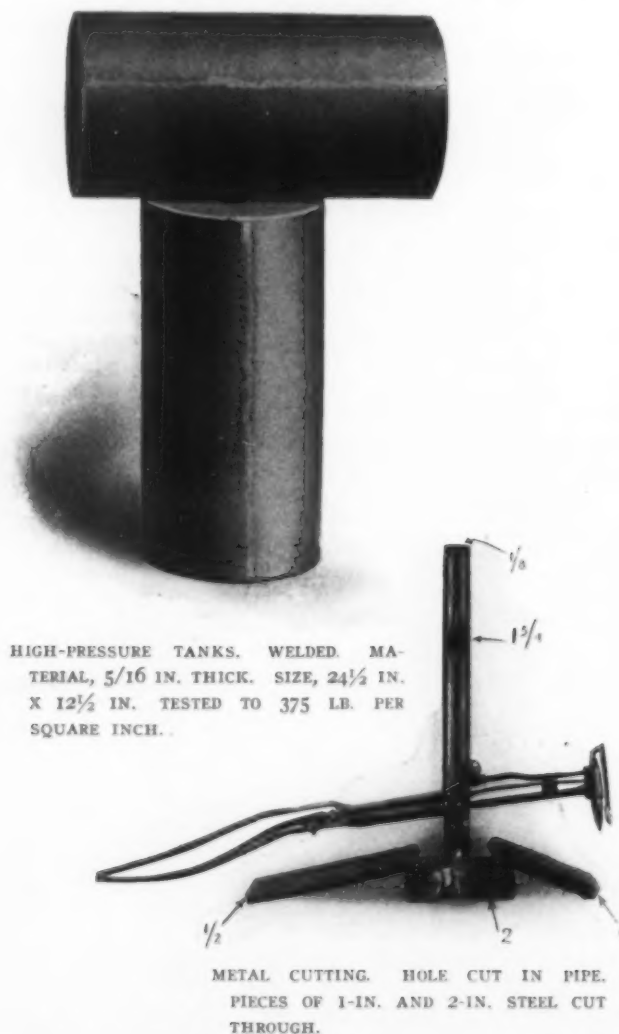
The welding plant comprises apparatus for generating both oxygen and acetylene and bringing the gases to the blow-pipes at any desired location in such a manner that exact regulation of the flame may be easily obtained by the workman.

In the case of oxygen it is necessary to have a reserve under a pressure of from 100 to 200 lbs. per square inch. The oxygen

when produced in the oxygen generator is passed through a washing and cooling device and then to the storage tank, which is fitted with the necessary gauges and valves. Acetylene is not used under a high pressure in the apparatus, it being only necessary to use a pressure of not exceeding 2 lbs. per sq. in., sufficient to ensure a constant flow of gas from generator to blow-pipe.

The charging of the oxygen generator with oxygenite does not take more than three minutes, while the generation of the oxygen gas takes from 20 to 40 minutes, according to the size of the charge. Any quantity of oxygenite, from 12 lbs. upward, liberates about 5 cu. ft. per lb. The acetylene is generated in a specially designed generator, which is specially designed and adapted for welding purposes.

A complete set of nozzles, 34 in number, is furnished by the Industrial Oxygen Company with each blow-pipe, enabling the



welder to adapt his blow-pipe to any desired thickness of metal and style of welding. Purchasers have the privilege of free instruction at the company's factory until proficient in the use of the blow-pipe (usually two or three days).

An interesting new development of which the Industrial Oxygen Company has taken hold is the cutting of metal plates by a special blow-pipe. As has been explained before in this journal (see especially the article of M. C. Schoop, our Vol. V, p. 308), the principle of the method is that when a steel plate is heated to a sufficiently high temperature and then a stream of oxygen is directed on the heated spot or line, spontaneous oxidation will take place immediately, resulting in a clean, sharp cut. This principle indicates at once the construction of the special burner

for cutting plates. It consists of an ordinary blow-pipe (for preheating the plate to the desired high temperature) combined with an additional oxygen-supply pipe through which a stream of oxygen is directed on the heated portion of the plate. The process has very decided advantages and should have a great future in this country. It is being used now to a large extent in Continental Europe.

Notes.

American Electrochemical Society.—At the August meeting of the board of directors, Dr. C. Schall, of the University of Leipzig, Germany, and Mr. Leonard C. Morgan, of the United States Mint, Philadelphia, were elected members of the society. At the September meeting the names of not less than 61 gentlemen will be presented for election. They are: Messrs Oscar F. Stevens, New York; James T. Hutchings, Rochester, N. Y.; F. W. Schiller, New York; John D. Hilliard, Albany, N. Y.; L. K. Comstock, Upper Montclair, N. J.; Langdon Albright, Buffalo, N. Y.; C. W. Parkhurst, Johnstown, Pa.; Robert Stuart Stewart, Detroit, Mich.; R. W. Stovel, New York; Clifton R. Hayes, Fitchburg, Mass.; L. W. Webb, Norfolk, Va.; Albert O. Benecke, Newark, N. J.; Thomas H. Yawger, Rochester, N. Y.; Sherman Coke Lloyd, Wilmington, Del.; John L. Yardley, Buffalo, N. Y.; Otto Kney, Madison, Wis.; Henry G. Reist, Schenectady, N. Y.; J. Franklin Stevens, Philadelphia, Pa.; L. H. Lathrop, Milwaukee, Wis.; William Hoopes, Pittsburg, Pa.; Albert Rockenbacher, Washington, D. C.; William N. Dickinson, New York; F. H. Willard, Rochester, N. Y.; Harry Le Vague Wills, Savannah, Ga.; J. Stanley Richmond, Toronto, Ont., Can.; Clarence D. Fitts, Oakville, Conn.; Jonathan W. Harris, New York; William J. Lansley, Perth Amboy, N. J.; Carleton A. Graves, Brooklyn, N. Y.; Ernest L. Doty, Buffalo, N. Y.; David J. Block, Chicago, Ill.; Edward E. Cary, New York; Joseph N. G. Nesbitt, Atlanta, Ga.; Edward Heitmann, Ampere, N. J.; Albert E. Peirce, Eau Claire, Wis.; James Joseph Dorney, St. Louis, Mo.; Leland L. Summers, Chicago, Ill.; Fred M. Sturgess, Pittsburg, Pa.; Lucius F. Hallett, Denver, Col.; John H. Ballweg, Baker City, Ore.; John B. Whitehead, Baltimore, Md.; C. J. Strossacker, Midland, Mich.; Charles J. Adsit, Warren, Ariz.; J. Frank Howard, Jersey Shore, Pa.; Thomas F. Judge, Woodland, Me.; Eugene H. Abadie, St. Louis, Mo.; Frank Davis Morgans, Columbus, Ohio; William S. Develin, New Castle, Pa.; Edwin S. Lincoln, Brookline, Mass.; M. Philip Sheridan, La Luz, Guanajuato, Mexico; Lloyd E. Knapp, Dallas, Tex.; E. M. Wilkins, San Luis Potosi, San Luis Potosi, Mexico; Frederick J. Neuman, Chicago, Ill.; A. H. Wellensiek, Aberdeen, S. D.; Arthur Williams, St. Louis, Mo.; W. L. Emery, Salt Lake City, Utah; Arthur T. Beasley, Coalinga, Cal.; Thomas E. Dainels, Richmond, Utah; Alanson N. Topping, Lafayette, Ind.; Camilo C. Cito, Irvington, N. J.; Edric Collingwood Creagh, Old Trafford, Manchester, England.

Dry Blast.—The Gayley dry-blast process, which was first tried on the Isabella Furnaces of the Carnegie Steel Company, in Pittsburg, with the well-known extraordinary results, is now extending its sphere of usefulness throughout the country. It has given excellent results at the Warwick Iron & Steel Company, at Pottstown, Pa. (see our January issue, page 12), at the South Chicago furnaces of the Illinois Steel Company, and at the Cardiff furnaces in Wales. Licenses for new installations of the Gayley process for blast furnaces have been granted to the Toledo Furnace Company, of Toledo, Ohio; the Federal Furnace Company, of Chicago, Ill.; the Northwestern Iron Company, of Mayville, Wis.; the Youngstown Sheet & Tube Company, of Youngstown, Ohio, and the Cleveland-Cliffs Iron Company, of Marquette, Mich. The process has also proven very satisfactory with the Bessemer plant at the South Works of the Illinois Steel Company.

Electric Steel Furnace.—A few editorial remarks in *The Iron Age*, Sept. 3, commenting on a letter in their correspondence

columns on the small Bessemer converter are interesting. They read as follows: "We may add that before many years we expect to see the 'baby' Bessemer completely overshadowed by the electric furnace in the steel foundry."

New York Electrical Show.—Mr. Thomas A. Edison has accepted the presidency of the New York Electrical Show, to be held in Madison Square Garden from Oct. 3 to 14, under the auspices of the large electric supply companies of New York and Brooklyn. Mr. T. C. Martin is the chairman of the advisory board.

Thermometry.—We have received from the Bristol Company, of Waterbury, Conn., their bulletins 91, 92 and 93, which cover all the types of Bristol recording thermometers up to 800° Fahr. The bulletins are interesting with respect to the surprisingly great variety of instruments described.

Electrogalvanizing.—We have received from the Meaker Company, of Chicago, a pamphlet entitled "Protection of Iron and Steel From Corrosion." The advantages of providing iron and steel with a protective zinc coating by electrolysis are pointed out, and a description is given of a machine made by the Meaker Company for a continuous galvanizing process. Zinc anodes are used with a special electrolyte, which is stated to give a dense, durable, glossy white deposit without development of hydrogen.

Sherardizing.—The process of sherardizing, invented by Mr. Sherard Cowper-Coles, for covering iron and steel articles with a zinc coating by treatment in contact with zinc dust at an elevated temperature, is now being introduced in this country by the United States Sherardizing Company, of New Castle, Pa. The process was described in detail in illustrated articles of Mr. A. Sang and of Mr. S. Cowper-Coles in our Vol. V, page 187, and in our Vol. VI, page 191, respectively.

Production of Coal.—The United States Geological Survey has just issued the statistical table on the production of coal in the United States from 1814, the date of the earliest record, to the close of 1907. The production has been increasing from year to year, almost without exception. The 100-million short-ton mark was passed in 1882, the 200-million ton mark was passed in 1897, the 300-million ton mark in 1902, and the 400-million ton mark in 1906. The production in 1905, 1906 and 1907 was 392,722,635 tons, 414,157,278 tons and 480,363,424 tons, respectively. The total production in the 94 years from 1814 to 1907 was 6,865,097,567 short tons.

Messrs. Dossert & Company, 242 West Forty-first Street, New York, have received an order for several hundred solderless lugs from the Trumbull Electric Manufacturing Company, of Plainville, Conn., for use on the panel and switchboards to be installed in the new Senate Building, Washington, D. C. The lugs vary greatly in size, and many of them are of special pattern in regard to the contact surface.

Pure Magnesium and Manganese.—We acknowledge receipt of a sample of metallic manganese, free from carbon, 98 to 99 per cent pure, from the Goldschmidt Thermit Company, of New York City. This pure manganese is made by the aluminothermic reaction and is of the greatest value in the brass and bronze industry. Messrs. C. E. Leavitt & Company, New York City, have sent us a sample bar of metallic magnesium over 99 per cent pure. (By a typographical error this was made to read manganese instead of magnesium on page 385, line five, of our last issue. This mistake will have been evident from the note that followed.) The chief use of magnesium is as a deoxidizer in foundry work. Metallic magnesium is made electrolytically.

Trigonometric Slide Rule.—We have received from Mr. M. J. Eichhorn, 5759 Aberdeen Street, Chicago, Ill., a description of his new "trigonometric slide rule," which is not intended to replace the well-known ordinary forms of slide rules, but rather to supplement them. Its special feature is a novel

method of graduation which enables an easy solution of the formula $C^2 = A^2 + B^2 - 2AB \cos c$, which gives the relation between the sides and angles of a triangle. The use of this new slide rule permits a considerable saving of time in solving any numerical problem of plane trigonometry.

The University of Cincinnati, Department of Chemistry, is introducing courses in chemical and metallurgical engineering and would be glad to receive, for their files, catalogues from manufacturers of machinery and appliances used in chemical and metallurgical industries.

The Dover Laboratory, chemists and assayers, of Dover, N. J., have sent us printed price lists for assays and determinations of various metals, coals, coke, limestones and clays. This laboratory was established in 1868, and is now conducted by Mr. Ethelbert Ely.

The Buffalo Foundry & Machine Company, Buffalo, N. Y., who besides making exceptionally large castings, are builders of vacuum drying and impregnating machinery, vacuum drum, shelf and rotary dryers, compressors, pumps, condensers and the Bell steam hammer, recently established a New York office at 143 Liberty Street, with Mr. H. E. Jacoby as resident engineer and manager of New York office.

New Electrolytic Process.—It is reported that work has been started on the erection of a plant of 100 tons capacity at Elkhorn, Mont., to treat tailings, of which there are 125,000 tons on the dump of the Elkhorn Silver Mining Company. The money has been subscribed by Helena people, and all arrangements perfected. The company expects to have the plant completed and in operation within the next few months. This plant will be worked under the Baker-Burwell patents (all of which have been noticed in our columns), and will be the first commercial plant in the United States of its kind. A test plant has been in operation for several months, and the efficiency of the methods demonstrated to the complete satisfaction of the stockholders of the Elkhorn Electrometal Company, which will build the plant under license granted by the Montana Metallurgical Company. The process to be used was described in an American Electrochemical Society paper of Mr. C. E. Baker, published in our Vol. V, page 448.

Personal.

Prof. **Joseph W. Richards**, of Lehigh University, who has spent the last three months in Italy, France and Switzerland, is expected to return in the beginning of October. Dr. Richards will attend the New York meeting of the American Electrochemical Society, of which he is the secretary, and intends to leave again in November for a trip to Europe and Asia.

The many friends of Mr. **George F. Brindley**, who was formerly connected with Mr. H. Y. Castner in England and then for 10 years the works manager of the Niagara Electrochemical Company until he left for Japan in 1906, will be glad to hear that he has returned to this country and is now in San Francisco.

Mr. **H. T. Matthew**, who has been the business manager of *ELECTROCHEMICAL AND METALLURGICAL INDUSTRY* almost from its start in 1902, has accepted the position as Western business manager of *Electrical World*, with headquarters in Chicago. Mr. Matthew is a member of the American Electrochemical Society, and has made a wide acquaintance and won many friends among chemical and metallurgical engineers and manufacturers. We are glad to announce that in his new field of activity Mr. Matthew will continue to represent this journal in the West. Mr. Matthew's successor as business manager of *ELECTROCHEMICAL AND METALLURGICAL INDUSTRY*, with headquarters in New York, is Mr. **J. M. Muir**, who has been connected with the McGraw Publishing Company for a number of years in the advertising departments of the *Street Railway Journal* and *Electrical World*, and has recently been in charge of the business department of the *American Telephone Journal*.

Digest of U. S. Patents.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

ELECTRIC FURNACES (Continued).

552,341, Dec. 31, 1895, J. A. Vincent and J. E. Hewes, Phila.

Arc type. The lower electrode is a horizontal block, supported in a hinged metal casing and closing the lower end of the furnace-chamber. The upper carbon-block electrode is vertically adjustable in a terra-cotta or fireclay tube by pendulum-controlled clockwork, being gradually and continuously raised in use. The charge is fed into the furnace from hoppers at opposite sides of the tube, by screws. Suitable for production of calcium carbide.

556,626, March 17, 1896, Adam Charles Girard and Ernest Auguste Georges Street, of Paris, France.

Arc type. Heats electrically-conductive materials in the form of bars or rods. The rod, constituting one electrode, is fed longitudinally through a chamber, and one or more arcs are sprung to it from the ends of lateral carbon electrodes. The furnace chamber is a carbon block surrounded, successively, with bricks of carbon, magnesia and fire-clay. The rod is fed by rollers and contact is made therewith by springs. The rod and carbon electrodes may pass through stuffing boxes and gas may be introduced into the chamber under regulated pressure. The rod may be replaced by a tube containing the material to be heated and closed by plugs. In a modified furnace, the rod or tube is fed through alined openings in the ends of parallel flat carbon bars, an arc being sprung from each to the rod or tube. The arcs may be caused to rotate by a magnetic field.

558,357, April 14, 1896, Michael R. Conley, of Brooklyn, N. Y.

Resistance type. The resistor is a trough-shaped vessel of plumbago and clay, inclined to a taphole at one end and closed by a lid. Three integral lugs project from each side of the vessel, the electric terminals being clamped thereto. Each connection is inclosed and cooled by a ring through which water is circulated, insulated by asbestos.

562,400, June 23, 1896, William R. King and Francis Wyatt, of New York, N. Y.

Arc type. The charge, e. g., for the production of calcium carbide, is fed from a hopper by a screw, through a vertical tube, into the upper end of a depending vertically-adjustable tubular carbon electrode, preferably constituting the anode. An arc is sprung from its lower end to a pan-shaped hearth below.

562,403, June 23, 1896, William R. King and Francis Wyatt, of New York, N. Y.

Resistance type. The furnace chamber is an open-topped structure of brick, having hollow walls filled with a bad conductor of heat and electricity, e. g., a mixture of lime and coke. A fixed carbon electrode projects into the lower end of the chamber and an adjustable carbon electrode depends into the upper end of the chamber. The charge-mixture, equal portions of pulverized coke and ground lime, is shoveled into the chamber, and a rod-core of carbon or coke is forced down through the mass till it touches the lower electrode. The upper electrode is then lowered upon it, lime and coke heaped around the point of contact and direct or alternating current is passed through the core to bring it to incandescence. A nugget of calcium carbide is thus produced, which is pulled out by tongs. The unreduced material falls into the bottom of the chamber and the operation is repeated.

562,404, June 23, 1896, William R. King, of New York, N. Y.

Arc type. The upper electrode consists of six depending carbon plates arranged in a circle to form a tube. Each plate is carried by an independently-adjustable stem. The several stems pass through a vertically-adjustable frame. The lower electrode is a pan-shaped hearth. The charge, e. g., for the manufacture of calcium carbide, is fed into a tube extending centrally into the tube of the central electrode, and thence falls onto a conical spreader.

567,699, September 15, 1896, Joseph A. Vincent, of Phila.

Furnace especially for the production of calcium carbide. The furnace has a vertical chamber with a hearth which recedes as the ingot of carbide or other smelted product increases. The furnace-body is of fire-brick, with an upper hopper and feed-screw. Horizontal carbon electrodes, supported on wheeled carriages and electromagnetically controlled, extend through lateral openings, the current passing between them and over the hearth. The hearth may be manipulated by a hydraulic cylinder or a screw. The gases escape by a lateral flue to a stack.

568,184, September 22, 1896, William L. Voelker, of Elizabeth, N. J.

Arc type. The furnace is a pot of calcium oxide, supported in a frame and having a lower opening for delivering the product, as it melts, into a mold below. Lateral electrodes of opposite polarity extend downward through openings in the side walls. The furnace is especially used for melting a mixture of lime and magnesia, with a coloring agent, for the production of materials for incandescing mantels.

569,221, October 13, 1896, Richard G. G. Moldenke, of Pittsburgh, Pa.

Arc type. Metals or alloys to be melted are placed in several pans of the same material, which also melt. Several of these pans, with their contents, are supported in line on an inclined shelf, constituting the hearth of a Siemens regenerative furnace. The charges gradually slide toward the edge of the shelf, where each is subjected to the action of an arc, sprung between converging carbon electrodes and blown inward by an electromagnet. The molten material flows into several crucibles or into a common hearth below. The furnace is used for melting scrap brass, bronze, or steel to which may be added ferrosilicon or ferromanganese.

569,911, October 20, 1896, Levitt E. Custer, of Dayton, Ohio.

Resistance type. Muffle for the manufacture of porcelain dental plates. The muffle is a closed box, having a hinged lid and lined with fire-clay. A tortuous resistance-wire of platinum is partially embedded in the inner faces of the top, bottom and side-walls. An external contact-arm enables sections of the wire to be connected in series or multiple, to furnish different temperatures. The furnace has two small openings in opposite sides, so arranged that a ray of light entering one opening will be reflected by the porcelain object and out through the other opening, thus enabling the temperature to be visually estimated.

NEW BOOKS.

THEORETICAL CHEMISTRY, FROM THE STANDPOINT OF AVOGADRO'S RULE AND THERMODYNAMICS. By Walter Nernst. Rev. in accordance with the fourth German edition. 295 pages. Bound in cloth. Price raised from \$3.75 net to \$4.50 net. New York: Macmillan.

THE DESIGN AND EQUIPMENT OF SMALL CHEMICAL LABORATORIES. By Richard K. Meade, B.S. 136 pages. Bound in cloth. Price, \$2 net. Chicago: The Chemical Engineer Publishing Co.

DESCRIPTIVE GENERAL CHEMISTRY: A TEXT-BOOK FOR SHORT COURSE. By Escue S. Tillman. Fourth edition and enlarged. 469 pages. Bound in cloth. Price, \$3 net. New York: John Wiley & Sons.

CHEMISTRY OF GAS MANUFACTURE. By Harold M. Royle. A practical manual for the use of gas engineers, gas managers and students. 343 pages. Bound in cloth. Price, \$4.50. New York: Norman W. Henley & Co.

THE PAPER MILL CHEMIST. By H. P. Stevens. 292 pages; illustrated. Bound in cloth. Price, \$2.50 net. New York: D. Van Nostrand Co.

IRON: ITS SOURCES, PROPERTIES AND MANUFACTURE. By W. H. Greenwood. With numerous engravings and diagrams (revised and partly rewritten by A. Humboldt Sexton). 272 pages; illustrated. 12°. Bound in cloth. Price, \$1. Philadelphia: David McKay.

LATHE DESIGNS FOR HIGH- AND LOW-SPEED STEELS. By T. J. Nicolson and Dempster Smith. A treatise on the kinematical and dynamical principles governing the construction of metal-turning lathes. With notes to guide the purchaser in the choice of a tool and many examples from practice. 414 pages; diagrams. Bound in cloth. Price, \$6. New York: Longmans, Green & Co.

A HANDBOOK OF ROCKS. By Ja. Furman Kemp. For use without the microscope; with a glossary of the names of rocks and of other lithological terms. 259 pages; illustrated. Bound in cloth. Price, \$1.50 net. New York: D. Van Nostrand Co.

A TEXT-BOOK OF IMPORTANT MINERALS AND ROCKS; WITH TABLES FOR THE DETERMINATION OF MINERALS. By Escue S. Tillman. Third edition, revised. 187 pages. Bound in cloth. Price, \$2 net. New York: John Wiley & Sons.

GAS POWER. By Franz Erich Junge. A study of the evolution of gas power, the design and construction of large gas engines in Europe, the application of gas power to various industries and the rational utilization of low-grade fuels. 561 pages; diagrams. Bound in cloth. Price, \$5. New York: Hill Publishing Co.

HOW TO USE WATER POWER. By Herbert Chatley. 92 pages; illustrated. Bound in cloth. Price, \$1 net. New York: D. Van Nostrand Co.

NOTES ON HYDRO-ELECTRIC DEVELOPMENTS. By Preston Player. 73 pages. Bound in cloth. Price, \$1 net. New York: McGraw Publishing Co.

HYDRO-ELECTRIC PRACTICE. By H. E. A. C. Von Schon. A practical manual of the development of water power, its conversion to electric energy and its distant transmission. 397 pages; diagrams. Bound in cloth. Price, \$6 net. Philadelphia: Lippincott.

GENERAL LECTURES ON ELECTRICAL ENGINEERING. By C. P. Steinmetz. Edited by Jos. Le Roy Hayden. 275 pages; 48 diagrams. Bound in cloth. Price, \$2 net. Schenectady, N. Y.: Robson & Adee.

HIGH-SPEED DYNAMO-ELECTRIC MACHINERY. By H. Hobart and A. G. Ellis. 545 pages. Bound in cloth. Price, \$6 net. New York: John Wiley & Sons.

THE DYNAMO: ITS THEORY, DESIGN AND MANUFACTURE. By Cesar C. Hawkins and F. Wallis. Fourth edition, with 413 illustrations; 938 pages. Bound in cloth. Price raised from \$3 net to \$3.25 net. New York: Macmillan.

NEW CATECHISM OF ELECTRICITY. By Nehemiah Hawkins. 550 pages; illustrated. Leather binding. Price, \$2. New York: Theodore Audel & Co.

ELEMENTS OF ELECTRICITY AND MAGNETISM: A TEXT-BOOK FOR COLLEGES AND TECHNICAL SCHOOLS. By W. Franklin and Barry MacNutt. 359 pages; diagrams. Bound in cloth. Price, \$1.60 net. New York: Macmillan.

PRACTICAL TREATISE ON THE STEAM ENGINE INDICATOR. By Nehemiah Hawkins. 268 pages. Bound in cloth. Price, \$1. New York: Theodore Audel & Co.

WATER SOFTENING AND PURIFICATION OF HARD AND DIRTY WATERS. By Harold Collet. 177 pages; illustrated. Bound in cloth. Price, \$2. New York: Spon & Chamberlain.

ELEMENTARY LESSONS IN HEAT. By Escue S. Tillman. Fourth edition, revised and enlarged. 196 pages; diagrams 8". Bound in cloth. Price, \$1.50 net. New York: John Wiley & Sons.

CALCULATING TABLES; GIVING THE PRODUCTS OF EVERY TWO NUMBERS FROM 1 TO 1000 AND THEIR APPLICATION TO THE MULTIPLICATION AND DIVISION OF ALL NUMBERS ABOVE 1000. By A. L. Crelle. New edition by O. Seeliger; with tables of the square-numbers and cube-numbers from 1 to 1000. Bound in cloth. Price, \$5. New York: Lemcke & Buechner.

THE PLANE TABLE AND ITS USE IN SURVEYING. By W. H. Lovell. 53 pages. Bound in cloth. Price, \$1 net. New York: McGraw Publishing Co.

BOOK REVIEWS

LEAD AND ZINC IN THE UNITED STATES. By W. R. Ingalls. Editor of the *Engineering and Mining Journal*. Illustrated. Price, \$4.00 net. New York: Hill Publishing Co.

This book is a rather new departure in technical literature, for it is the first to our knowledge that deals with the historical and economic side of the question and only gives such practical information as will help to throw into relief the commercial outlines of the subject. The thought has been often expressed by us in our editorial pages that the modern engineer should above all else know the broad principles of business as well as the broad principles of chemistry and physics in order to direct the new and marvelous forces that are now placed at his disposal. The "*raison d'être*" of Mr. Ingalls's latest work is to fill this much-felt want.

We can thus heartily commend his energy in preparing such a book, amid the cares and responsibilities of editorial life.

Lead and zinc, as every one in the metal trade knows, are almost always associated together in ore deposits, usually in limestone country rocks. The minerals are separated first by some mechanical process as by "jigging" and "tabling." Later other separation processes, such as the electrostatic and the magnetic processes or the flotation process, are used. A great number of different forms of treatment are known and the procedure is to use a combination of processes. Finally, as a general rule, we have three salable products; a lead concentrate, and iron-lead concentrate, and a zinc concentrate. The first goes to the lead smelter as a collector in smelting silicious gold-silver ores, and the second is used as flux in the same operation. The third is sold to a zinc plant. This is the outline treatment of complex ores. Some zinc-lead ores are simple as those of the "Joplin" district and produce simply a high-grade zinc product and a high-grade lead product. In some lead ores as those of the Cœur d'Alene district zinc is present in such forms and percentage as to be neither a serious obstacle nor a by-product.

Lead ores are roasted, for galena is usually now the main commercial mineral. The roasted product is smelted with coke in shaft furnaces to "base bullion." This is desilverized by the Parkes process. Zinc ores are roasted to less than one per cent sulphur and mixed with non-coking carbonaceous material, charged in 50-lb. retorts heated with gas, natural or artificial.

The presence of zinc is detrimental to the lead-smelter and the presence of lead detrimental to the zinc-smelter. The two metals which dwell so harmoniously in the deposits are metallurgically antagonistic and even compete with each other in the paint trade as white lead and zinc white.

The metallurgy of both lead and zinc is far from satisfactory and, especially is the treatment of "complex" ores, wasteful and expensive. Lead smelting is far ahead of its position ten years ago, due to the so-called "pot" roasting and the careful study of slags by the late Septimus Austin.

Mr. Ingalls traces the developments of extracting the metals from the crude beginnings of a pile of wood and stones, the hand jigs of Joplin to the "Scotch" hearth, the magnificent mills treating "sheet" ground in Joplin and the modern smelting plants at Pueblo. He is a careful worker and gleaner of facts and the result is much to be admired. There are, of course, slips, such as the description of the plant of the St. Louis S. & R. Co. as a "Scotch-hearth" plant. To the best of our knowledge, it is a short blast furnace with settling chambers and bag house resembling the Scotch hearth plant only in its use of blast and a filtration. We also believe that it would have been advisable to give a little more of the picturesque history of the pioneer lead smelters. More illustrations would have also redounded to the attractive qualities of the book.

There is one very interesting bit of information to which we have before alluded in our editorial columns. That is the fact that the Cowles brothers bought 25 years ago a zinc-copper-lead mine in New Mexico. They endeavored to perfect an electric

smelting process. This was unsuccessful, but their work with the electric furnace was the beginning of all the electric furnace work of the last decade as well as the reduction of aluminium. Mr. Ingalls errs in the influence of this early work, restricting it to what he calls "aluminium smelting."

We also believe that Mr. Ingalls's habit of quoting so often from his past writings does not lead to a pleasant impression on the reader. It suggests to him that Mr. Ingalls is shirking the work of finding a new expression for his thoughts—which, of course, he is not.

One part of his work that is particularly to be commended is the analysis of the use of a knowledge of trade conditions on the part of the dominating lead company toward the extraction of the maximum monopolistic profit in the lead business both by long ore-contracts and control of the consuming companies' stock instead of by relying on metallurgical efficiency. Comparing the present and future of the American S. & R. Co. with the United States Steel Corporation, we can see that Mr. Ingalls's arraignment is both fair and courageous. To again criticize the book we would state that in our opinion it were wise to analyze fully the consumption of spelter for galvanizing, brass, sheet zinc, etc., and also to add to the rather meagre information given about the consumption of lead.

Summing up, we can state that this book, like all the other works of the author, is much to be admired and should receive much attention from the interested metallurgical public. The book is to form a part of the Economic History of the United States and thanks are due to the Carnegie Institution for its assistance to the publisher and author. We believe it would have been in better taste for the former not to print the names of the several journals which he publishes on the title page of a book which had been prepared with the assistance of an institution whose aims are philanthropic. This gives a commercial coloring to what should be a dignified and high-toned effect. We are sure the author cannot be sponsor for this.

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SYNTHETIC INORGANIC CHEMISTRY. By Arthur A. Blanchard, Ph.D. 12 mo.; '89 + viii pages. Cloth. Price, \$1.00 net. New York: John Wiley & Sons.

This book covers a laboratory course for first-year students who have had a general course in the chemistry of the non-metallic elements. The ideas of the author on the subject of the teaching of chemistry of the metallic elements as advanced in the preface should be brought to the attention of all our colleges. The experiments as given for general chemistry are so quickly formed and alike as to awaken no interest in the student. Qualitative analysis is too one-sided for this work, and the only other alternative, the preparation of a number of inorganic reagents and commercial products seems to be the most satisfactory solution of the problem. And with one exception this little book is well adapted to carry out this idea. It gives the object of the exercise, with an outline of the principle of the work involved, followed by exact working directions which if carefully followed will assure satisfactory products, and a series of questions for class-room review.

The exception to the above is the presumption of a knowledge of the dissociation theory and the principle of mass action. Of this latter we might pass over, but it has been the general experience of the reviewer in the teaching of chemical principles to even much more advanced than first-year students that the theory of electrolytic dissociation is a dangerous tool to put into such inexperienced hands. The student on seeing this: "thus if sodium nitrate and potassium chloride are dissolved together in water the resulting solution will contain Na^+ , K^+ , NO_3^- and Cl^- ions" . . . is almost certain to overlook the ionic fact and expect the atomic or even molecular condition instead. To present an idea so easily misconstrued to the student is hardly right. Every reaction mentioned in the book can be completely explained without the use of this theory, which in general is

more a hindrance than a help to the class of men this book is intended to reach.

In general, the arrangement is all that could be desired, and the preparations selected are quite characteristic of both their class of elements and of commercial practice. The book should find a place in the preliminary work of all our courses in general chemistry, it not being intended to supplement the larger works on industrial chemical preparations. An index should have been included, by all means.

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LABORATORIUMSBUCH FÜR DEN METALLHÜTTENCHEMIKER. By H. Nissenson and Dr. W. Pohl. 86 + ix pages. Paper. Price, 3 marks. (Retail price in New York, \$1.00.) Halle a. S., Germany: Wilhelm Knapp.

This, the second volume of the series of laboratory books for the chemical and allied industries, is concerned with the occurrence, qualitative examination and quantitative estimation of the elements aluminium, antimony, arsenic, lead, chromium, gold, cadmium, copper, manganese, molybdenum, nickel, platinum, mercury, silver, thorium, uranium, tungsten, zinc and tin. The book is only intended for the guidance of experienced chemists in the laboratory and not as a text or instruction book for novices.

No claim is made for completeness of schemes, the only ones given being the most reliable of present technical laboratory methods and those in the briefest possible form. Separations are given for some of the elements, more should be given; for instance, that troublesome element zinc is left quite untouched in this regard. Some of the newer methods as the bismutate method for manganese should have found place therein.

The book lacks that very necessary adjunct, an index, though its place is more or less satisfactorily filled with a detailed Table of Contents. The proof-reading for a work of this kind has been most carelessly done, a list of appended corrections not covering half the errors noted by the reviewer.

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THERMODYNAMICS OF TECHNICAL GAS REACTIONS. Seven lectures by Dr. F. Haber, professor at the Institute of Technology in Karlsruhe. Translated by Arthur B. Lamb, Ph.D., director of the Havemeyer Chemical Laboratory, New York City. 356 pages, 20 illustrations. Price, \$3.00. New York: Longmans, Green & Company.

This is an authorized translation of Prof. Haber's noteworthy and highly suggestive "Thermodynamik Technischer Gasreaktionen," which was reviewed in our Vol. IV, page 333.

The English edition is, however, more than a mere translation. It is rather a new edition. Many parts have been rewritten and account has been taken of the progress made during the last few years in chemical thermodynamics. Extensive appendices have been added to three of the lectures; they are of special interest with respect to the standpoint which Haber takes toward Nernst's new thermodynamical theorem.

Dr. Lamb, in his preface, sums up the situation very well in these words: "The fascinating possibility of predicting the course of a chemical reaction from a few characteristic constants of the reacting substances seemed very far from realization after the ill-starred attempt of Berthelot. Recent attacks upon this problem have been more successful, and the future is promising."

As we noticed in our former review, the book has been written for the sake of the chemical engineer rather than the theorist. Haber's discussion of such actual engineering problems as the fixation of atmospheric nitrogen or the water-gas reaction, will certainly be found exceedingly interesting and suggestive. However, it is by no means easy reading. It requires not only familiarity of the reader with the chemical and engineering aspects of the subjects discussed, but also some training in higher mathematics.

The translator has done his work well.